Abstracts

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Molecular cloning and sequence analysis for Δ-pyrrolin-5-carboxylate synthetases from mangrove plants, A. MORIYA and F. SAKAI: *Wood Res.*, No. 85, 62–65 (1998).

A Δ-pyrroline-5-carboxylate synthetase (P5CS) gene fragment was isolated from mangrove *(Bruguiera sexangula)* genomes by polymerase chain reaction (PCR). The cloned PCR products were sequenced completely, and harbored putative 9 exons. The deduced amino acid sequence of No. 11 and No. 12 exons showed high similarity (80–90%) with those encoded by known genes for NADPH binding domain.

Detection of embolism and acoustic emissions in tracheids under a microscope, K. KURODA, H. KURODA and A.M. LEWIS: *IAWA Journal,* **19**, 463–464 (1998).

We observed embolism in light-microscope sections of diseased pine trees and confirmed the relationship between bubble development and acoustic emissions (AEs) that are detected at embolism. The AEs coincided with almost all of the rapid bubble development. Two weeks after inoculation of the pathogen nematodes, water blockage by embolism had just occurred in a part of the xylem. In such trees, the time necessary for rehydration is longer than in healthy trees. It suggests that certain substances that inhibit bubble dissolution may exist in xylem.

Changes in levels of mRNAs for cell wall-related enzymes in growing cotton cells, Y. SHIMIZU, Y. IHARA, R. TOMINAGA, F. SAKAI and T. HAYASHI: *Wood Res.*, No. 85, 59–61 (1998).

The levels of mRNAs for cell wall-relating enzymes (endo-1, 4-β-glucanase, endo-1, 3-β-glucanase, endoxyloglucan transferase, sucrose synthase, expansin and cellulose synthase pcsA1 and pcsA2) were determined in both fibers and seedlings of cotton by reverse transcription-PCR analysis.

Cloning of cotton homologs of bcsA gene encoding cellulose β-1, 4-glucosyltransferase, Y. IHARA, F. SAKAI and T. HAYASHI: *Wood Res.*, No. 85, 56–58 (1998).

The full length cDNA of *pcsA2* has been obtained by the 5′ RACE method and the PCR technique. The cotton *pcsA2* which appears to be a full length clone of 3,311 bp contains an open reading frame of 3,120 bp that encodes a polypeptide of 1,039 amino acids with calculated molecular mass of about 125 kDa.

Enhancement of cellulose production by expression of sucrose synthase in *Acetobacter xylinum,* T. NAKAI, N. TONOUCHI, T. KONISHI, Y. KOJIMA, T. TSUCHIDA, F. YOSHINAGA, F. SAKAI and T. HAYASHI: *Proc. Natl. Acad. Sci. USA,* **96**, 14–18 (1999).

Higher plants efficiently conserve energy ATP in cellulose biosynthesis by expression of sucrose synthase, in which the high free energy between glucose and fructose in sucrose can be conserved and used for the synthesis of UDP-glucose. Here, we constructed a mutant SuSy to mimic phosphorylated SuSy and used it for bacterial cellulose synthesis. The mutant sucrose synthase in which Ser^{11} was replaced with Glu using site-directed mutagenesis enhanced the reaction efficiency (Vmax/Km) due to higher affinity for sucrose, suggesting that the Glu^{11} mimics the phosphorylated Ser11 of the enzyme because phosphorylation may occur in the serine residue in mung bean sucrose synthase. A mixture of mutant sucrose synthase and bacterial cellulose synthase proceeded to form UDP-glucose from sucrose plus UDP and to synthesize cellulose from the sugar nucleotide. The incorporation of glucose from sucrose was increased in the decreasing concentrations of UDP in the reaction mixture probably because UDP inhibits cellulose synthase. This shows that sucrose synthase functions the prevention of UDP build-up in the coupled reaction between UDP-glucose and cellulose syntheses. The expression of sucrose synthase in *A. xylinum* not only changed sucrose metabolism but also enhanced cellulose production, in which UDP-glucose was efficiently formed from sucrose resulting in massive synthesis of cellulose.

Occurrence of cello-oligosaccharides in the apoplast of auxin-treated pea stems, R. TOMINAGA, M. SAMEJIMA, F. SAKAI and T. HAYASHI: *Plant Physiol.*, **119**, 249–254 (1999).

Treatment of pea hypocotyl segments with indole-3-butyric acid, which promotes segment elongation, increased the solubilization of not only xyloglucan but also cello-oligosaccharides in the apoplast of auxin-treated pea stems. The cello-oligosaccharides were isolated from the apoplastic solution by the use of charcoal/Celite column and identified as cello-biose, -triose and -tetraose by after subsequent TLC and paper electrophoresis. Cello-oligosaccharides in the apoplastic fraction were monitored using cellobiose dehydrogenase. Both xyloglucan and cello-oligosaccharides appeared to be formed concurrently within 30 min after treatment with the auxin, and the cello-oligosaccharides increased with stem elongation even after 2 h. Nevertheless, the total activity of cellulase did not increase up to 4 h.

***In situ* synthesis of β-glucan microfibrils on tobacco plasma membrane sheets,** N. HIRAI, S. SONOBE and T. HAYASHI: *Proc. Natl. Acad. Sci. USA,* **95**, 15102–15106 (1998).

A major concern in plant morphogenesis is whether the microtubules are responsible for the arrangement and action of β-glucan synthases in the plasma membrane. We have prepared an isolated plasma membrane sheet with cortical microtubules attached (prepared membrane sheet) and attempted that β-glucan synthases penetrate through the membrane to form microfibrils, moving in the fluid membrane along the cortical microtubules. This technique enables us to measure β-glucan synthesis as a fiber with a two-dimensional structure. The synthesis of β-glucan microfibrils was directed in arrays by cortical microtubules at many loci on the prepared membrane

sheet. The microfibrils were mainly arranged along the microtubules but some were crossing over the microtubules. The rate of β-glucan elongation directly determined on the exoplasmic surface was 550 nm per min. When the assembly of microtubules was disrupted by the treatment with propyzamide, the β-glucans were not deposited in arrays but in masses. This shows that the arrayed cortical microtubules are not required for β-glucan synthesis but required for the formation of arranged microfibrils on the membrane sheet.

Gene for cellulose 4-β-glucosyltransferase, T. HAYASHI: *Cellulose Commun.,* **6**, 2–6 (1999).

Many putative genes for the catalytic subunit of cellulose synthase have been cloned and sequenced from many organisms, particularly higher plants, by genom projects. The amino acid sequences of the gene products are highly similar to those of bacterial cellulose 4-β-glucosyltransferases. The gene structures and their proposed reaction mechanisms are discussed for our overall understanding of cellulose biogenesis.

Cellulose metabolism, T. HAYASHI: *In* Plant hormones and Cell Shapes, ed. H. Imaseki and H. Shibaoka, *Gakkai Publishers,* Tokyo, 121–129 (1998).

The cellulose metabolism of higher plants by hormones was reviewed.

Enhancement of cellulose deposition by mutant sucrose synthase, T. HAYASHI, T. NAKAI and T. KONISHI: *Second International Wood Science Seminar,* Serpong, Indonesia, D12, 6–7 Nov. (1998).

The review described a plant sucrose synthase which serves to channel carbon directly from sucrose to cellulose.

An increase in apparent affinity for sucrose of mung bean sucrose synthase is caused by *in vitro* phosphorylation or directed mutagenesis of Ser^{11}, T. NAKAI, T. KONISHI, X.-Q. ZHANG, R. CHOLLET, N. TONOUCHI, T. TSUCHIDA, F. YOSHINAGA, H. MORI, F. SAKAI and T. HAYASHI: *Plant Cell Physiol.* **39**, 1337–1341 (1998).

A mutational analysis of mung bean (*Vigna radiata* Wilczek) sucrose synthase was performed by site-directed mutagenesis of the recombinant protein expressed in Escherichia coli, in which two different acidic amino acid residues (Asp or Glu) were introduced at Ser^{11} (S11D, S11E). Only the wild-type enzyme (Ser^{11}) was phosphorylated in vitro by a Ca^{2+}-dependent protein kinase from soybean root nodules, suggesting that this is the specific target residue in mung bean sucrose synthase. The apparent affinity for sucrose was increased in this phosphorylated enzyme and also in the S11D and S11E mutant enzymes, although the affinities for UDP-glucose and fructose were similar in the wild-type, phosphorylated wild-type, and mutant enzymes. These results suggest that a monoanionic (1^{-}) side chain at position 11 mimics Ser11-P2-residue to bind and cleave sucrose for the synthesis of UDP-glucose. Since the S11E mutant enzyme showed a higher catalytic efficiency in recombinant enzymes, the enzyme properties of the S11E mutant enzyme were further characterized. The results showed that replacement of Ser^{11} with Glu^{11} conserved the activity against phenolic glycosides and changed its nucleotide specificity. We postulate that the introduction of a negative change into Ser^{11} is involved in the enzymatic perturbation of sucrose synthase.

Control of expression by the cellulose synthase (bcsA) promoter region from *Acetobacter xylinum* BPR 2001, T. NAKAI, A. MORIYA, N. TONOUCHI, T. TSUCHIDA, S. HORINOUCHI, Y. SONE, H. MORI, F. SAKAI and T. HAYASHI: *Gene,* **213**, 93–100 (1998).

The 5′ upstream region (about 3.1 kb) of cellulose synthase operon (*bcs* operon) has been isolated by cloning from *Acetobacter xylinum* strain BPR 2001. The expression level of the upstream region was determined using sucrose synthase cDNA as a reporter gene in the shuttle vector pSA19. The expression occurred with the 1.1-kb upstream sequence from the ATG start codon of *bcs* operon but not with the 241-bp upstream sequence in *A. xylinum,* although neither 1.1-kb nor 241-bp upstream sequence caused any expression as a promoter in *Escherichia coli.* The level of expression with the 1.1-kb upstream sequence in *A. aceti* was 75% of that in *A. xylinum.* These results suggest that the upstream region functions as a specific promoter for *Acetobacter* genus. The expression was reduced by the introduction of the 241-bp upstream region between the *lac* promoter and the reporter gene in *E. coli* and was not detected in *A. xylinum.* This suggests that the short upstream region composed of 241-bp contains the site(s) which causes a negative regulation on the transcription for *bcs* operon. The production of recombinant protein with the ribosome-binding site (RBS) of *A. xylinum* obtained from the *bcs* operon, was reduced to about half in *E. coli,* and that with the site of lac promoter was also reduced to about half in *A. xylinum.* This shows that a species-specific predominance occurs during interaction between mRNA and 16S rRNA in the RBS between *A. xylinum* and E. coli.

Enhancement of cellulose production in *Acetobacter xylinum,* T. NAKAI, N. TONOUCHI, T. KONISHI, T. TSUCHIDA, F. YOSHINAGA, F. SAKAI and T. HAYASHI: In Advanced Research in Biodegradable Polymers, ed. A. Steinbuchel, pp. 128–133, Wiley-VCH Verlag, Weinheim (1998).

The review described that sucrose synthase serves to channel carbon directly from sucrose to cellulose in bacterial cells.

Purification and characteristics of a novel cytochrome *c* dependent glyoxylate dehydrogenase from a wood-destroying fungus *Tyromyces palustris*, T. TOKIMATSU, Y. NAGAI, T. HATTORI and M. SHIMADA: *FEBS Letters,* **437**, 117–121 (1998).

A new glyoxylate dehydrogenase which catalyzes dehydrogenation of glyoxylate to oxalate in the presence of cytochrome *c* has been purified as an electrophoretically homogeneous protein from the cell-free extracts of a wood-destroying basidiomycete *Tyromyces palustris.* The enzymatic reduction of cytochrome *c* was dependent on glyoxylate which was found to be the best substrate among the compounds tested. Km value for glyoxylate was

determined to be 2.7 mM at the optimal pH 8.0. The UV-visible spectra of the enzyme in oxidized and reduced forms indicate that the enzyme belongs to a family of flavohemoproteins. The flavin nucleotide isolated from the native enzyme by heat denaturation was identified as FMN. The enzyme (Mr; 331,000) consists of six identical homopolymers (Mr of subunit; 59,000), which were found to constitute a symmetric octahedral shaped by the electron-microscopic observation with a negative staining method.

Stereochemical difference in secoisolariciresinol formation between cell-free extracts from petioles and from ripening seeds of *Arctium lappa* L., S. SUZUKI, T. UMEZAWA and M. SHIMADA: *Biosci. Biotech. Biochem.,* **62**, 1468–1470 (1998).

Cell-free extracts from ripening seeds of *Arctium lappa* L. catalyzed the enantioselective formation of (−)-pinoresinol, (−)-lariciresinol and (−)-secoisolariciresinol from achiral coniferyl alcohol in the presence of NADPH and H_2O_2. The enantioselectivity of the lignan formation was opposite to that of the (+)-secoisolariciresinol formation catalyzed by cell-free extracts from petioles of the same plant species.

Cloning of *Phanerochaete chrososporium* leu2 by complementation of bacterial auxotrophs and transformation of fungal auxotrophs, L.S. ZAPANTA, T. HATTORI, M. RZETSKAYA and M. TIEN: *Appl. Environ. Microbiology,* **64**, 2624–2629 (1998).

A *Phanerochaete chrysosporium* cDNA library was constructed in an expression vector that allows expression in both *Escherichia coli* and *Saccharomyces cerevisiae*. A number of genes were cloned by complementation of bacterial amino acid auxotrophs. The cDNA encoding the β-isopropylmalate dehydrogenase from *P. chrososporium* was characterized further. The genomic clone (gleu2) was subsequently isolated and was used successfully as a selectable marker to transform *P. chrysosporium* auxotrophs for LEU2. The method described here allows other genes to be isolated from *P. chrysosporium* for use as selectable markers.

Production and protection of woods based on bioscience of symbiotic and saprophytic fungi, M. SHIMADA: *Proceedings of the Second International Wood Science Seminar,* November 6–7, Serpong, Indonesia, p. A1 (1998).

Several biochemical roles of organic acids, including oxalic acid produced by symbiotic and saprophytic fungi are discussed in relation to wood biodegradation and production for permanent sustainable forest utilization. Recent finding of a new oxalic acid producing enzyme from wood-rotting fungi and the positive effect of the ectomycorrhizal fungi on growth of pine seedling roots in the symbiotic system are described.

A biochemical role of oxalic acid biosynthesis in forest fungi and enzymes involved: Toward protection and production of woods, M. SHIMADA, T. TOKIMATSU, Y. NAGAI and T. HATTORI: *Proceedings of the Second International Wood Science Seminar,* November 6–7, Serpong, Indonesia, p. D9 (1998).

We have discoverd, from a brown-rot fungus *Tyromyces palustris*, a new oxalate producing enzyme or a flavohemoprotein glyoxylate dehydrogenase which has never been reported from any kingdom of plants, animals, and microorganisms. Characteristics of the enzyme is discussed in relation to important basic and applied work for forest science and biotechnology in future.

Chemistry and biochemistry of lignan biosynthesis, T. UMEZAWA, S. SUZUKI, T. OKUNISHI, K. MIKAME and M. SHIMADA: *Proceedings of the Second International Wood Science Seminar,* November 6–7, Serpong, Indonesia, p. D10 (1998).

We have demonstrated that two enzyme preparations from different organs of *Arctium lappa* can catalyze the selective formation of different enantiomers of a lignan. The results indicate that different stereochemical mechanisms can operate even in different organs of a single plant species.

A possible role of organic acids during symbiosis between woody plants and mycorrhizal fungi, T. HATTORI, G.S. SEO, N. AKITSU, A. OHTA and M. SHIMADA: *Proceedings of the Second International Wood Science Seminar,* November 6–7, Serpong, Indonesia, p. D11 (1998).

We have successfully synthesized symbiotic system with *Pinus densiflora-Lactarius hatsudake* ecomycorrhizae in a vermiculite containing glucose and yeast extract. Oxalate was found to be a major organic acid produced in the symbiotic culture. The roles of the organic acids in the symbiosis between *Pinus densiflora* and *Lactarius hatsudake* are discussed.

Syringaresinol isolated from *Paraserianthes falcataria,* LISWIDOWATI, W. SYAFII, S. SUZUKI, T. UMEZAWA and M. SHIMADA: *Proceedings of the Second International Wood Science Seminar,* November 6–7, Serpong, Indonesia, p. E19 (1998).

Syringaresinol was isolated from *Paraserianthes falcataria* for the first time. The results suggest that *Paraserianthes falcataria* contains biologically active syringaresinol diglucoside and a potential application of this plant to tonics or pharmaceuytical usage.

Different distribution of cellulose synthesizing complexes in brittle and non-brittle strains of barley, S. KIMURA, N. SAKURAI and T. ITOH: *Plant & Cell Physiol.* **40**(3), 335–338 (1999).

The cause of low cellulose content in brittle mutants of barley was studied. No differences were found in the dimension of crystalline cellulose microfibrils among mutant and normal strains by X-ray diffraction analysis. By contrast, the number of cellulose synthesizing terminal complexes (TCs) in a selected brittle mutant, Kobinkatagi 4, decreased to one fifth of that in the normal strain. These findings suggest that the low cellulose content in brittle mutants of barley is caused by the decrease in the number of TCs on its plasma membrane.

Tunic morphology and cellulosic components of pyrosomas, doliolids, and salps (thaliacea, urochordata), E. HIROSE, S. KIMURA, T. ITOH and J.

NISHIKAWA : *Biol. Bull.* **196**, 113–120 (1999).

The morphology and cellulosic composition of the tunic was studied in pelagic tunicates (3 pyrosomas, 2 doliolids, and 13 salps). The tunic is transparent and gelatinous, consisting an electron-dense cuticular layer with a fibrous tunic matrix. The thickness and density of the cuticular layer and of the tunic matrix differ from species to species. In some salps, the cuticular layer has numerous minute protrusions that are structurally identical to those found in several ascidians. Free mesenchymal cells (tunic cells) are distributed in the tunic. Whereas the number of tunic cells in the pyrosomas is similar to that in ascidians, there are many fewer tunic cells in doliolids and salps. These differences may be caused by the different functions of the tunic in each group. The existence of cellulose in the tunic was confirmed using electron diffraction in all of the species studied thus far. Their diffractograms indicate that the cellulose microfibrils consist of nearly pure Iβ of the allomorph. These results show that tunic morphology and cellulosic composition are similar in ascidians and thaliaceans (pyrosomas, doliolids, and salps). The tunic is considered to be a homologous tissue in these animals, and their most recent common ancestor would have possessed this tissue.

Effect of ions on the orientation of cortical microtubules in spirogyra cells, K. IWATA and T. ITOH : *Plant & Cell Physiol.* **39**, 1099-1103 (1998).

Effects of ions on the orientation of cortical microtubules (MTs) in Spirogyra cells were studied. After depolymerization with amiprophos-methyl (APM), MTs were allowed to reorganize in NaCl solutions of various concentrations. As the concentration of NaCl increased, the frequency of cells that had oblique MTs increased. When cells in NaCl solution were transferred into artificial pond water (APW) and incubated for 6 hr, all the MTs changed to become transverse to the longitudinal axis of the cell. KCl and $MgCl_2$ also had effects on the orientation of MTs. However, NH_4Cl, $CaCl_2$, $CoCl_2$, and $Co(NO_3)_2$ did not show any effect. These results suggest that Na^+, K^+, and Mg^{2+} have effects on MT orientation and that NH_4^+, Ca^{2+}, Co^{2+}, Cl^-, and NO_3^- have little effect. When MTs were reorganized in either NaCl or KCl solutions, all the oblique MTs were organized into an S-helix. In contrast, some of the oblique MTs were found as a Z-helix in the cells incubated in $MgCl_2$ or mannitol solutions. These results suggest that effects of Na^+ and K^+ on the orientation of MTs are not the same as those of Mg^{2+} and mannitol. These results provide the first evidence that ions are involved in the orientation of MTs in algae.

A new cellulosic structure, the tunic cord in the ascidian, *Polyandrocarpa misakiensis*, S. KIMURA and T. ITOH : *Protoplasma* **204**, 94–102 (1998).

A specialized structure of tunic cord in *Polyandrocarpa misakiensis* is investigated by electron microscopy. The tunic cord is a cord-like coiled structure of 5–30 μm in diameter and 0.1–9.0 mm in length. The tunic cords are originated and elongated from the dorsal tunic, and their terminus have a swollen and ornamented structure. Scanning, transmission electron micrographs and electron diffractogram shows that the tunic cords are composed of bundled microfibrils of cellulose I with high crystallinity. The tunic cord is completely surrounded by single layered epidermal cells, which have been found as the site of cellulose biosynthesis. A number of tunic cords are connected to internal tunic of siphon by forming eyelet structures at their terminus. These observations suggest that the tunic cords act as a connector between dorsal and internal tunic of siphon.

Cell wall architecture prerequisite for the cell division in the protoplasts of white poplar, *Populus alba* L., K. SUZUKI, T. ITOH and H. SASAMOTO : *Plant & Cell Physiol.*, **39**(6), 632–638(1998).

White poplar (*Populus alba* L.) protoplasts were investigated in the stage of 0, 3, 10, 20 and 30 days after regeneration to visualize the cell wall architecture prerequisite for cell division. The 10 day-old cells just before cell division developed a thin wall layer with uneven deposition of cell wall materials and were saved from bursting after suspending them in low osmotic medium. The three dimensional architecture of the cell wall, as revealed by rapid-freezing and deep-etching electron microscopy, in 10 day-old cells were covered with thin innermost lamellae on the plasma membrane along with highly extended microfibrillar networks. These results suggest that the deposition of thin lamellae is important not only for cells to withstand bursting but also to induce cell division. The present investigations give the first account of the visualization of the three-dimensional architecture of regenerated cell wall right before cell division.

Localization of xyloglucan in cell wall of suspension culture of tobacco by rapid-freezing and deep-etching techniques coupled with immunogold labelling, K. SUZUKI, K. BABA, T. ITOH and Y. SONE : *Plant & Cell Physiol.*, **39**(10), 1003–1009 (1998).

Localization of xyloglucan in cell walls regenerated from tobacco protoplasts (*Nicotiana tabacum* L.; cv. BY-2) is visualized by rapid-freezing and deep-etching (RFDE) electron microscopy coupled with immunogold electron microscopy. Xyloglucan has already deposited in cell wall 3 hr after culture initiation. Xyloglucan is mainly localized along microfibrils with lesser amount in a intersection between two crossed microfibrils in 120 hour-old cells. These evidences support the previous hypothesis of Keegstra *et al.* (1973) that show the interconnection between xyloglucan and cellulose.

Change in pectin structure during epidermal cell elongation in pea *(Pisum sativum)* and its implications for cell wall architecture, T. FUJINO and T. ITOH : *Plant & Cell Physiol.*, **39**(12), 1315–1323 (1998).

Changes in cell wall architecture during elongation of epidermal cells in pea epicotyls were visualized by rapid-freezing and deep-etching (RFDE) techniques. An abundant network structure composed of the association of granular substances disappeared from the cell wall during elongation. The granular substances were demonstrated to be pectic polysaccharides by their disappearance upon EDTA treatment and by chemical analysis of the EDTA-

extractable substances. It is proposed that the association of the granular substances is involved in the swelling of the cell walls in the elongating region. Two observations suggest that the formation of the pectic gel itself is not involved in controlling the wall porosity. Labelling with the monoclonal antibody JIM5, which recognizes unesterified pectins, was much more extensive in the cell walls of the non-elongating region compared to those in the elongating region. The pore size of the cell wall is greater in non-elongating than elongating region.

Periodicity of xylem growth of rubberwood *(Hevea brasiliensis)* grown in Malaysia, N.R.A. JALIL, T. ITOH, H. SAHRI and Z. JUSOH : *Holzforschung,* **52**, 567–572 (1998).

A study on the periodicity of xylem growth in rubberwood tree at a plantation at University Putra Malaysia, Serdang, Malaysia, was conducted using a dendrometer and, pinning and knife-cutting methods. From the dendrometer readings, actual radial growth showed that no substantial increase during the first six months of the study period. Growth started in the seventh month (July) and continued until the end of the year, after which the tree once again entered a resting period; possibly due to wintering effects at the beginning and end of the year. These results were also supported by pinning and knife-cutting experiments where the scars from the first (January) to the fifth month (May) occurred on previous distinct rings. It can be concluded that the rubberwood studied here showed continuous growth over a year period with a resting stage at the beginning and the end of the growth cycle. This suggests that rubberwood trees produce one growth ring a year. The present study showed that pinning or knife-cutting methods coupled with dendrometer measurements are suitable for elucidating the correlation between growth rings and periodicity of xylem growth.

Anatomical description of Japanese hardwoods IV, T. ITOH : *Wood Res. and Tech. Notes,* No. 34, 30–166 (1998).

The anatomical characteristics of Japanese hardwoods classified from Anacardiaceae to Araliaceae covering 109 species, among 56 genera and 29 families are described. The photomicrographs of cross, radial and tangential sections covering 109 species are also presented.

Tree species for wooden artifacts excavated from the Akanoi-Wan Site, Akanio-Wan Site the forth separate volume, *Biwako-Kaihatsujigyou-kanren-Maizou-Bunkazai-Hakkutsu-Chous-Houkokusho,* **2**, 139–164 (1998).

A large number of wooden artifacts were excavated from the Akanoi-Wan Site at the bottom of Lake Biwa. The wood species from samples of 2,152 pieces were identified microscopically, resulting in the finding of 52 taxa. Among all, Cryptomeria in coniferous wood and Cyclobalanopsis in hardwood were abundant. It was reduced that the forest superior in Cryptomeria species was present in the south of Lake Biwa area.

Enzymatic hydrolysis of bacterial cellulose., M. SAMEJIMA, J. SUGIYAMA, K. IGARASHI and K.-E.L. ERIKSSON : *Carbohydr. Res.,* **305**, 281–288 (1998).

Native cellulose from the bacterium *Acetobacter xylinum* as well as acid-treated bacterial cellulose prepared from partial hydrolysis of the native bacterial cellulose with 2.5 N HCl were subjected to enzymatic hydrolysis by *Trichoderma viride* cellobiohydrolase I (CBH I) and endoglucanase II (EG II). The activities of the two enzymes were continuously monitored with an oxidation-reduction potential electrode based on the cellobiose dehydrogenase-ferricyanide redox system. The individual CBH I and EG II hydrolyzed both native and acid-treated bacterial cellulose in a similar way. While CBH I rapidly hydrolyzed both cellulose samples, the ability of EG II to hydrolyze these samples was very limited. However, the hydrolytic behavior of the two cellulose samples by the combination of the two enzymes was significantly different. The rate of hydrolysis of the native bacterial cellulose increased drastically with the combination of the two enzymes, while no synergistic increase in hydrolysis rate was observed with the acid-treated cellulose. Electron microscopy demonstrated that the synergistic action of CBH I and EG II for the native bacterial cellulose involved drastic disintegration of the twisted and bent ribbon-like structure of microfibril bundles and gave rise to the formation of linear, needle-like microcrystallites. Thus, the ribbon-like structure of microfibril bundles in the native bacterial cellulose seems to have a high susceptibility for the combined action of the two enzymes. In contrast, the microfibril aggregates of the acid-treated bacterial cellulose were not disintegrated by the combination of the two enzymes. From these observations, it seems reasonable to assume that differences in the assembling pattern of the microfibrils must be one of the major reason for the significant differences in the synergism of the two enzymes for the two bacterial cellulose samples.

Surface structure of native cellulose microcrystals by AFM, A.A. BAKER, W. HELBERT, J. SUGIYAMA and M.J. MILES : *Appl. Phys. A,* **66**, S559–S563 (1998).

Atomic force microscopy (AFM) has been used to study the surface of native cellulose I microcrystals from *Valonia ventricosa.* High-resolution images show clear structural detail of the surface, namely the 0.52 nm repeat along the cellulose chains resulting from the glucose sub-unit and the inter-molecular spacing of ~0.6 nm. Cellulose from *Valonia* exists naturally in both a triclinic ($I\alpha$) and a monoclinic ($I\beta$) crystal form within the same microfibril; the main difference between them being a displacement of adjacent chains by a quarter of the *c*-axis period to give either a diagonally shifted or staggered arrangement of the cellobiose units. The most significant finding in this work is that is has been possible to image the cellobiose repeat along the chain because of topographic differences associated with the asymmetric glucose unit, and thus identify triclinic structure on the microcrystal surface. Computer modeling has been used to construct pseudo-AFM topography images from Connolly surfaces of the faces of the two different crystal forms, and the triclinic models are in excellent agreement with the real images obtained by AFM.

High resolution electron microscopy of cellulose II and α-chitin single crystals, W. HELBERT and J.

SUGIYAMA: *Cellulose,* **5**, 113–122 (1998).

Single-crystalline cellulose II and α-chitin regenerated from low-molecular weight solutions using phosphoric acids as a solvent were investigated by electron diffraction together with high-resolution imaging. Two types of cellulose II were regenerated by precipitation either in water (DP=15) or in ethanol (DP=7), and the latter revealed better crystalline perfection. In both cases, the structures are in good accord with the previously published 2-chain monoclinic model. Although the lattice fringes of base planes of the crystal were identified by Fourier transform of negatives, the precise localization of cellulose molecules was not visualized due to local azimuthal fluctuation of the crystal. α-chitin was regenerated by precipitation only in ethanol. The crystals are flat ribbons with a smooth surface and, in structure, fit well a previous antiparallel-chain model because their a^*b^* electron diffraction patterns agrees well with the proposed $P2_12_12_1$ symmetry. Two-dimensional lattice images were obtained with a resolution up to 0.38 nm. Molecular packing in the unit cell was clearly demonstrated with the help of image processing, and corroborated by kinematical calculation of high-resolution images of α-chitin.

High resolution electron microscopy on ultrathin section of cellulose microfibrils generated by glomerulocytes in *Polyzoa vesiculiphora*, W. HELBERT, J. SUGIYAMA, S. KIMURA and T. ITOH: *Protoplasma,* **203**, 84–90 (1998).

Glomerulocyte cellulosic bundles of *Polyzoa vesiculiphora* were investigated by microdiffraction and high resolution electron microscopy. In each bundle, hundreds of cellulose microfibrils, having a rectangular cross sectional shape, are packed regularly with their 0.6 nm lattice planes parallel to each other. Lattice images reveal that the 0.6 nm plane is parallel to the longer edge of the cross section which is similar to the lattice organization of *Valonia* cellulose having a squarish cross section. More interestingly, all the microfibrils in a bundle have the same directionality of crystallographic *c*-axis, which suggests that the biosynthesis of the microfibrils within particular bundle occurs unidirectionally.

Unidirectional action of cellobiohydrolase I on *Valonia* microcrystals, T. IMAI, C. BOISSET, K. IGARASHI, M. SAMEJIMA and J. SUGIYAMA: *FEBS Lett.,* **432**, 113–116 (1998).

On the basis of "parallel-up" structure of the cellulose crystal, a crystallographic approach to study the mode of action of cellobiohydrolase Cel7A on *Valonia* cellulose microcrystal has been carried out. After incubation with Cel7A, most of the initially smooth and well defined *Valonia* microcrystals fibrillation. However as the hydrolysis reaction was rather heterogeneous, some microcrystals remained superficially intact. Close investigation on such crystals revealed polar morphology : one end was narrowed extremely or pointed. Electron microdiffraction analyses on these crystals evidenced that the narrowing of the microcrystals occurs at their reducing end side. This was also confirmed by the visualization of selective reducing end labeling at the pointed ends of microcrystals. These lines of investigation are the first demonstration that the processivity of Cel7A action against insoluble highly crystalline celluloses is unambiguously toward non-reducing ends from reducing ends.

Nanodomains of Iα and Iβ cellulose in algal microfibrils, T. IMAI and J. SUGIYAMA: *Macromolecules,* **31**, 6275–6279 (1998).

Ultrastructural localization of cellulose Iα and Iβ allomorphs in one microfibril from algal sources was investigated using electron microdiffraction. Both cellulose Iα and Iβ were characterized as one-chain triclinic and two-chain monoclinic unit cells respectively, in agreement with previous studies. These two structures coexisted in each microfibril, alternating either longitudinally or laterally. The transition zone between the two phases was found to be the interface between adjacent H-bonded molecular sheets (i.e. 0.39 nm lattice planes).

Crystalline features of bacterial cellulose altered by chemical agents during biosynthesis, K. ABE, J. SUGIYAMA, T. ITOH, M. ISHIHARA and S. YAMANAKA: *Wood Res.,* No. 85, 66–67 (1998).

We found that the addition of several reagents induced the modification of cell morphology of *Acetobacter*. Two chemicals were found to elongate cells by inhibiting the separation after the cell division. Another reagent, a reducing reagent, effectively shortened the cell on the contrary. We present a preliminary results on the changes of microfibrillar morphology induced by such chemical reagents

Molecular imaging of *Halocynthia papillosa* cellulose, W. HELBERT, Y. NISHIYAMA, T. OKANO and J. SUGIYAMA: *J. Struct. Biol.,* **124**, 42–50 (1998).

The molecular organization of cellulose Iβ microfibrils in the tunic of *Halocynthia papillosa* was analyzed by high resolution cryo-electron microscopy on ultra-thin cross-sections of artificially highly-oriented microfibrils. The arrangement of cellulose chains intersected by the 0.6 nm, 0.53 nm and 0.39 nm equatorial lattice planes was clearly imaged over the whole area of a parallelogram-shaped cross-section of a microfibril. One edge of the parallelogram was parallel to the 0.6 nm lattice plane, while the other did not correspond to a crystallographic plane. Such organization is distinct from previous findings on algal cellulose Iα-rich microfibrils, which have an almost square cross-section bounded by both 0.6 nm and 0.53 nm crystallographic planes. A tentative model for microfibril formation is proposed by introducing a two-step biocrystallization mechanism: the formation of molecular sheets spaced by 0.53 nm between adjacent molecules, followed by self-deposition of these sheets by hydrogen-bonding between them.

Molecular directionality of β-chitin biosynthesis, J. SUGIYAMA, C. BOISSET, M. HASHIMOTO and T. WATANABE: *J. Mol. Biol.,* **286**(1), 247–255 (1999).

The molecular packing in β-chitin unit cell was experimentally determined by a combination of unidirectional degradation by *Bacillus circulans* chitinase A1 and microdiffraction electron crystallography using highly

crystalline β-chitin microfibrils from the protective tubes secreted by *Lamellibrachia satuma*. The mode of chain packing was found to be identical to that of the previously published crystal model for β-chitin despite a controversial definition of the unit cell parameters. In this study, a "parallel-down" packing was determined, where the reducing ends of chains point opposite to the crystallographic *c*-axis. Microdiffraction analyses of nascent β-chitin microfibrils generated from diatom *Thalassiosira* sp. showed that the *c*-axis of the crystal was directed toward the diatoms, and therefore the reducing end of a growing chain pointed away from the locus of biosynthesis. This mechanism agreed well with what we found recently in the cellulose biosynthesis system, and provides strong evidence that the polymerization by the processive glycosyl transferase takes place at the non-reducing end of the growing polysaccharide chains.

Aspects of native cellulose microfibrils at molecular resolution, J. SUGIYAMA and T. IMAI: *TIGG (Trends in Glycosci. Glycotechnol.)*, **11**(57), 23–31 (1999) (bilingual).

Native cellulose is one of the best studied natural polymers. Cellulose is synthesized by the coordinated action of enzymatic polymerization coupled with instant crystallization into nascent cellulose microfibrils. This mechanism allows generation of highly extended chains that can crystallize into microfibrils including two distinct crystalline moieties; cellulose Iα and Iβ. The microfibrils are then assembled to form higher order structures such as layers, cell walls, fibers and tissues. Structural analyses of cellulose have been performed to determine both its primary structure and higher order structures as these markedly influence the function and properties of native cellulose. Here, we report recent advances in our knowledge regarding the structure of native cellulose at several different levels.

Elucidation of biogenesis from structural studies on cellulose, J. SUGIYAMA: *APAST*, No. 30, 15–17 (1999) (in Japanese).

A strategy to determin the molecular directionality of cellulose biosynthesis is briefly outlined.

Molecular directionality of cellulose biosynthesis, J. SUGIYAMA: *Denshi Kenbikyou*, **34**, 55–57 (1999) (in Japanese).

A technical details of electron microscopy to determin the molecular directionality of cellulose biosynthesis is discussed.

Approaches to the mechanisms of reaction wood formation, K. BABA: *Wood Research and Technical Notes*, No. 34, 1–6 (1998) (in Japanese).

The variation and changes of approaches to the mechanisms of reaction wood formation were reviewed.

Preparation of synthetic lignin by manganese peroxidase of *Bjerkandera adusta* in organic solvents, S. YOSHIDA, A. CHATANI, M. TANAHASHI, Y. HONDA, T. WATANABE and M. KUWAHARA: *Holzforschung*, **52**, 282–286 (1998).

Manganese peroxidase (MnP) of *Bjerkandera adusta* oxidized guaiacol and 2, 6-dimethoxyphenol more efficiently than horseradish peroxidase (HRP) in the reaction mixture containing 70% acetone. MnP of this fungus also catalyzed the polymerization of monolignols in the reaction mixture containing 70% acetone. The molecular weight of these dehydrogenation polymers (DHPs) is higher than those prepared by HRP under the same conditions. The chemical structure of DHP polymerrized by MnP is similar to that of native lignin.

Reaction of manganese peroxidase of *Bjerkandera adusta* with synthetic lignin in acetone solution, S. YOSHIDA, A. CHATANI, Y. HONDA, T. WATANABE and M. KUWAHARA: *J. Wood Sci.*, **44**, 486–490 (1998).

The reaction of manganese peroxidase (MnP) of the white-rot fungus *Bjerkandera adusta* with synthetic lignin (dehydrogenasion polymer, DHP) in acetone medium was investigated. Gel-permeation chromatography of the syringyl DHP in the reaction mixture containing 70% acetone; moreover, concomitant repolymerization occurred to give highly polymerized products. Guaiacyl DHP was only repolymerized by MnP in the same acetone solution without giving degradation products. Addition of ascorbic acid to reaction mixtures containing acetone resulted in preferential depolymerization of syringyl DHP.

Bio-processes for the utilization of lignocellulose, M. KUWAHARA: *Bioscience and Industry*, **56**, 22–25 (1998) (in Japanese).

Lignocellulosic resources including wood biomass are potentially utilizable as the industrial feedstock in stead of fossil resources. Current researches on the microbial and enzymatic conversion of components of these resources are reviewed.

Copper-dependent depolymerization of lignin in the presence of fungal metabolite, pyridine, T. WATANABE, K. KOLLER and K. MESSNER: *J. Biotechnol.*, **62**, 221–230 (1998).

Thus far it has not been reported that copper complexes are able to depolymerize lignin at ambient temperature in aqueous media. However, we have found that both phenolic and non-phenolic lignins were intensively depolymerized by Cu(II) and lipid hydroperoxide model compounds in the presence of a metabolite of ligninolytic fungi, pyridine at room temp in aqueous solutions. The copper system was also effective for pulp bleaching. This finding not only introduces a new concept of non-enzymatic lignin biodegradation but also presents a new strategy for decomposing lignin and lignin-related compounds by copper complexes and peroxide-producing system.

Physico-chemical characteristics of soluble lignin fractions released from forage grasses by ruminat digestion, T. KONDO, T. WATANABE, T. OHSHITA and T. KYUMA: *JARQ*, **32**, 187–195 (1998).

Structural modification of forage grass lignin during ruminant digestion was analyzed. Fecal-soluble lignin isolated after digestion by ruminant animals was rich in syringylpropane units and contained less phenolic components compared with milled hay lignin which was

prepared from original grasses. Molecular size of the fecal-soluble lignin was smaller than that of the milled hay lignin. Similar physico-chemical properties were also found in a dioxiane-soluble lignin fraction isolated from rumen digesta of the ruminant animals.

Development of physiological functions of cellooligosaccharides, T. WATANABE : *Cellulose Commun.*, **5**, 91–97 (1998) (in Japanese).

Physiological functions of cellooligosaccharides and their derivatives were reviewed. Cellobiose functioned as an indigestible sugar in healthy humans while it was hydrolyzed in the small intestine of rats there by increasing the blood glucose level. Cecal fermentation of cellobiose predominantly produced butyric acid which is known as an important fuel and powerful differentiating agent for the colon epithelial cells. To evaluate long-term intake of the oligosaccharide, rats were kept for 4 weeks on a high sucrose diet with or without the cellobiose supplement. After 4 weeks, body fat, serum level of fructosamine, total cholesterol, and triglyceride decreased by use of the cellobiose supplement, suggesting that cellooligosaccharides are beneficial for preventing diabetes and obesity.

Isolation of the gene encoding the iron-sulpher protein subunit of succinate dehydrogenase from *Pleurotus ostreatus,* Y. HONDA, T. IRIE, T. MATSUYAMA, T. WATANABE and M. KUWAHARA : *Proc. Genet. Cell. Biol. of Basidiomycetes IV,* p. 166, Nijmegen, The Netherlands, 27–30, Mar. (1998).

We are interested in developing techniques for gene cloning and transformation in *Pleurotus ostreatus* that can be used for strain improvement and permit us to combine molecular and biochemical analysis of the enzymes involved in lignin degradation. To this end, we have set out to isolate a gene that may be used to develop a transformation system. In the plant pathogenic species *Ustilago maydis,* a single amino acid substitution (His257 to Leu) in the gene that encodes the Iron-sulphur protein (Ip) subunit of succinate dehydrogenase (EC 1.3.99.1) has been shown to confer a dominant resistance to the systemic fungicide carboxin. A similarly modified gene from *P. ostreatus* would provide a potentially valuable selective marker for the development of transformation vectors. We have shown that dominant mutations to carboxanilide resistance can occur in *P. ostreatus*. Here, we describe the isolation and characterization of the gene encodine the *P. ostreatus* Ip subunits as a first step.

Genomic and cDNA fragments encoding the *P. ostreatus* Ip subunit of succinate dehydrogenase have been cloned using PCR techniques. The gene is interrupted by five introns and is predicted to encode a polypeptide of 268 amino acid residues. Sequence comparison with the Ip subunit from other species identified three conserved cysteine-rich clusters. One of these contains a critical histidine residue implicated in carboxin sensitivity in *U. maydis*.

Isolation and sequence analysis of the promoter and an allelic sequence of the iron-sulfur protein subunit gene from the white-rot fungus *Pleurotus ostreatus,* T. IRIE, Y. HONDA, T. MATSUYAMA, T. WATANABE and M. KUWAHARA : *J. Wood Sci.,* **44**, 491–494 (1998).

We have isolated a structural gene of *sdi1*, which encodes iron-sulfur protein (Ip) subunit of succinate dehydrogenase (EC 1.3.99.1), from a white-rot basidiomycete, *Pleurotus ostreatus*. Here we report the isolation of the promoter region of *sdi1* and an allelic sequence encoding the second-type cDNA fragment isolated in the former experiments. The nucleotide sequence analysis of the promoter region revealed the existence of putative CAAT and TATA boxes, which permits us to develop an expression system in this species. The Southern blot analysis and the restriction fragment length polymorphism using monokaryotic strains demonstrated that no family genes to *sdi1* exist in the haploid genome of *P. ostreatus*. Moreover, a genetic analysis to detect a linkage between the *sdi1* genotypes and the flutolanil-resistance in the mutant *P. ostreatus* strains was also developed.

Amino acid substitutions in a pheromone alter *B*-mating type specificity of *Coprinus cinereus,* Y. HONDA and L.A. CASSELTON : *Proc. 6th MSJ Int'l symposium,* p. 89, Chiba, 26–27, Nov. (1998).

Specific interactions between mating type pheromones and their transmembrane receptors have been reported to be essential in self and non-self recognition systems in many eukaryotic microorganisms. In order to investigate the specific mechanism for *B*-mating type recognition in basidiomycete *Coprinus cinereus*, a mutational analysis of a pheromone gene was undertaken. Mutant genes encoding for chimeric pheromone between *B6* and *B42* alleles were constructed by site-directed mutagenesis in *phb 3.2* (*B6*) gene. Recombinant plasmids carrying these constructs were transformed into wild-type strains and the mating type activity of their gene products was assayed by crossing transformants against a suitable tester strain. Among the four positions which are different in amino-acid sequences between *B6* and *B42* alleles, none of the single amino-acid substitutions at the first, second and fourth positions made any differences, compared to wild-type control. Moreover, a deletion of two amino-acids around the first position did not change the activity and the deleted pheromone still possessed *B6*-specificity. However, a single substitution at the third position, F to W, made the transformants self-compatible in both of *B6* and *B42* background, indicating the loss of the pheromone specificity. Furthermore, a double mutant at the third and fourth positions, FW to WF, reversed the pheromone specificity from *B6*- to *B42*-type. These results suggested that the two amino acids, which are followed by the CAAX box, play significant roles in specific recognition of the pheromone by the corresponding receptor in these alleles.

The compressive stress relaxation of albizia (*Paraserienthes falcata* Becker) wood, W. DWIANTO, T. MOROOKA and M. NORIMOTO : *Mokuzai Gakkaishi,* **44**(6), 403–409 (1998).

To clarify the mechanisms for the perfect fixation of compressive deformation of wood by heat treatment, measurements of stress relaxation at a strain level of 50% in the radial direction for oven-dried albizia (*Paraserienthes falcata* Becker) wood specimens were made for 24 hours during heat treatments in the temperature range of 20 to

200°C. In the temperature range of 100 to 140°C, almost the same normalized stress relaxation curves was observed; the stress decreased continuously with time above 160°C and the extent of stress decrease was increased with increasing temperature. The stress disappeared in about 20 hours at 180°C and in about five hours at 200°C. The weight loss of specimens after 24 hours increased gradually up to 140°C and remarkably above 160°C. An excellent correlation between the recovery of deformation or the residual stress and the weight loss was observed, and the relationship was expressed by a hyperbolic equation. The residual stress was proportional to the recovery of deformation, and this fact suggested that the perfect fixation of deformation resulted from the release of stresses stored in the cell wall polymers by their degradation by the heat treatment.

Permanent fixation of compressive deformation of albizia wood *(Paraserienthes falcata)* by heat treatment, W. DWIANTO, T. MOROOKA and M. NORIMOTO : *J. Tropical Forest Products,* **4**(1), 59–67 (1998).

Three heating methods, i.e. air heating, vacuum heating and molten metal heating were examined for the permanent fixation of compressive deformation of albizia wood, *Paraserienthes falcata*. The recovery of compressive deformation decreased with increasing weight loss. Perfect fixation was attained at about 4% weight loss. The retention of modulus of rupture at the perfect fixation was about 75%. The relationship between recovery of set and weight loss was expressed by a hyperbolic equation regardless of heating method. The permanent fixation of compressive deformation was speculated to have resulted from the release of stresses stored in the microfibrils and the matrix substance of the cell wall due to their degradation.

Radial compression of sugi wood (*Cryptomeria japonica* D. Don), W. DWIANTO, M. NORIMOTO, T. MOROOKA, F. TANAKA, M. INOUE and Y. LIU : *Holz als Roh- und Werkst.,* **56**(6), 403–411 (1998).

This paper deals with the heat fixation of compressive deformation of sugi wood (*Cryptomeria japonica* D. Don) which is a typical Japanese coniferous wood with a low density. After wet specimens were compressed in the radial direction to about 50% of their original thickness and dried under restraint, they were subjected to heat treatment by three methods : beneath the surface of molten metal, and in the presence or absence of air. The relationship between the recovery of deformation and the weight loss was expressed by a hyperbolic equation regardless of heating methods. The retentions of the MOE and the MOR of compressed specimens at the perfect fixation were 89% and 81%, respectively. The perfect fixation of deformation was speculated to have resulted from the release of stresses stored in the cell wall polymers by their degradation as well as the reduction of hygroscopicity of the cell wall polymers.

The viscoelastic behavior of Japanese lacquer film II, The changes of viscoelastic properties due to heat treatment, E. OBATAYA, Y. OHNO, K. UMEMURA and M. NORIMOTO : *Mokuzai Gakkaishi,* **44**(5), 327–331 (1998).

The storage modulus (E') of Japanese lacquer films rapidly increased with time at temperatures above 100°C and remained unchanged at temperatures below 50°C. The increasing rate of E' increased with increasing temperature in the early stage. The films shrunk remarkably at temperatures above 150°C. The loss modulus (E'') of the films heated at various temperatures for 12 hours had two peaks in the temperature range of 100°C to 200°C and at about −140°C, labeled α and γ respectively. The α loss peak was attributed to the micro-Brownian motions of lacquer molecules. The temperature location of the α loss peak had the largest value when the film was heated at 250°C. Both the α peak and the apparent activation energy of the α relaxation process showed the smallest values when the film was heated at 200°C. These results suggested that heating promoted the cross-linking formation of the lacquer molecules at temperatures below 200°C and their remarkable degradation at temperatures above 250°C.

Viscoelastic properties of the matrix substance of chemically treated wood, M. SUGIYAMA, E. OBATAYA and M. NORIMOTO : *J. Materials. Sci.,* **33**(14), 3505–3510 (1998).

The temperature variations of the storage modulus and the loss tangent along the grain for four kinds of chemically modified Sitka spruce (*Picea sitchensis* Carr.) woods were measured at 11 Hz over a temperature range of −150 to 200°C. By using a cell-wall model in which the amorphous matrix substance is disposed parallel to the axis of cellulose fibrils inclined at an angle to the grain direction of the wood, the storage modulus, E_m, and the loss tangent, $\tan\delta_m$ of the matrix substance were estimated, and the relaxation processes detected were discussed. In formalization, the restriction of the micro-Brownian motion of the main chains due to oxymethylene bridges between the hydroxyl groups resulted in a decrease in $\tan\delta_m$ above 0°C. In acetylation and propylene oxide treatment, a marked reduction in E_m was observed over the temperature range tested, by the introduction of bulky side chains, and the $\tan\delta_m$ remarkably increased in the high-temperature range. In polyethylene glycol (PEG) impregnation, the E_m increased below 20°C due to the freezing of the micro-Brownian motion of PEG molecules in the cell lumens as well as in the cell walls, while it was reduced above this temperature by the melting of PEG molecules.

Liquid penetration of precompressed wood VI, Anatomical characterization of pit fractures, U. WATANABE, Y. IMAMURA and I. IIDA : *J. Wood Sci.,* **44**(2), 158–162 (1998).

Pit fractures of refractory coniferous heartwoods caused by precompression in the radial direction were investigated and were discussed in terms of improved liquid penetration. Small cracks appeared at the boundary between the torus and margo and along the outer margin of the margo, as well as on the torus, when specimens were compressed and deformation was fixed by drying set. The remarkable cracks were generally observed for *Cryptomeria japonica* D. Don. *Pseudotsuga menziesii* Franco showed peculiar detachment of the torus from the pit

border, while *Larix leptolepis* Gordon exhibited only small cracks on the torus. These fractures patterns were more clear when the precompressed specimens were recovered by water-impregnation and then re-dried.

Mechanical and dielectric relaxations of wood in a low temperature range II, Relaxation due to adsorbed water, M. YOKOYAMA, E. OBATAYA and M. NORIMOTO: *Mokuzai Gakkaoshi,* **45**(2), 95–102 (1999).

The dynamic viscoelastic and dielectric measurements in the longitudinal direction of Sitka spruce (*Picea sitchensis* Carr.) heart wood were made in the temperature range of −150°C to 0°C. The storage modulus and loss modulus in the viscoelastic measurement were measured at frequencies of 1 Hz, 3.5 Hz, 11 Hz, and 33 Hz in the moisture content range of 3.3% to 21.1%, and dielectric constant and dielectric loss (ε'') in the dielectric measurement were measured at 50 Hz, 110 Hz, 1 kHz, 10 kHz and 100 kHz in the frequency range of 3.8% to 35.2%. A relaxation due to the adsorbed water in both measurements was observed in the temperature range tested. When compared at 33 Hz, the relationship between the temperature location at a loss maximum and moisture content was almost identical in both the measurements. The apparent activation energy of the relaxation due to the adsorbed water in both the measurements decreased up to 12–13% moisture content and then increased. These results suggested that the viscoelastic and dielectric relaxations due to the adsorbed water resulted from the same mechanism.

The effects of water soluble extractives on the acoustic properties of reed (*Arundo donax* L.), E. OBATAYA, T. UMEZAWA, F. NAKATSUBO and M. NORIMOTO: *Holzforschung,* **53**(1), 63–67 (1999).

The storage modulus (E') and the loss tangent ($\tan\delta$) of reed (*Arundo donax* L.) used for woodwinds were measured at 20°C and 60% relative humidity and the effects of water soluble extractives on these properties were discussed. The extractives increased both the E' and $\tan\delta$ of reed. There was a linear relationship between the $\tan\delta$ change and the weight loss due to extraction. By using an uniaxial rheological model considering the anatomical structure of reed, the E' and $\tan\delta$ of reed were described using the storage moduli, loss tangents, and volume fractions of bundle sheaths and parenchyma cells. It was suggested that the extractives in parenchyma cells increased the modulus of elasticity for parenchyma cells by 25% and reduced the relaxation time of parenchyma cells by a fact of three. The main constituents of extractives were glucose, fructose and sucrose.

Tangential Young's modulus of coniferous early wood investigated using cell models, U. WATANABE, M. NORIMOTO, T. OHGAMA and M. FUJITA: *Holzforschung,* **53**(2), 209–214 (1999).

The relationship between the tangential Young's modulus and the transverse cell shape in coniferous early wood was investigated by using cell models constructed by power spectrum analysis. The calculated Young's moduli of the cell models explained qualitatively the change of the experimental Young's moduli with density as well as the difference in the experimental values among species. The calculated Young's moduli differed significantly among species depending on the cell model shapes when compared at the same density. With increasing element angle in the model, the Young's modulus greatly increased without a significant change in the density, especially at the larger ratios of the axial length of the tangential cell wall to that of the radial cell wall.

Suitability of acetylated woods for clarinet reed, E. OBATAYA: *J. Wood Sci.,* **45**(2), 106–112 (1999).

The density (ρ), dynamic Young's modulus (E), loss tangent ($\tan\delta_L$) in the longitudinal (L) direction, and the dynamic shear modulus (G), loss tangent ($\tan\delta_S$) in the LT or LR (T, tangential; R, radial) plane of woods and cane (*Arundo dondx* L.) in air-dried and wet conditions were measured. The acoustic converting efficiency (ACE), expressed by $(E/\rho^3)^{1/2}/\tan\delta_L$, and the factors of anisotropy, expressed by E/G and $\tan\delta_S/\tan\delta_L$, of woods were compared with those of the canes. Low-density coniferous woods had higher ACE values and were of a more anisotropic nature than the cane. These woods seemed appropriate for clarinet reed owing to their homogeneous cellular structure. The stability in vibrational properties and the anticreep properties of the woods were enhanced by the acetylation treatment. Professional clarinet players suggested that acetylation Glehn's spruce and Sitka spruce were suitable for clarinet reeds.

History of termite-controlling chemicals, M. TAKAHASHI: The Memorial Publication of the Forty Years Anniversary of Japan Termite Control Association, 83–96 (1998) (in Japanese).

A trend of termite-controlling chemicals was reviewed since the ban of chlordane in 1986. Initially dominant organic phosphates are going to be placed for other chemicals including synthetic pyrethroids. Most of new termiticides are categorized as "designated chemical substance" mainly due to their lower degradability but some of them are allowed to use by the low mammalian toxicity and low-dosage effectiveness. Non-chemical termite control is getting the place besides the chemical control but non-emotional "risk/benefit assessment" on current termite control should be progressed in several aspects.

Global ecosystem and termites/wood preservation, K. TSUNODA: *Wood Res. and Tech. Notes,* **34**, 22–29 (1998) (in Japanese).

Termite control is a serious problem to our life because termites have been economically important pests to wooden houses and other related cellulosic materials since human beings started building houses with wood and cultivating crops. Novel techniques without the aids of chemicals were briefly introduced. Brief overview of the role of termites in the global ecosystem was described with a special emphasis on their contribution to the global warming by methane emission. Significance of wood preservation was also discussed in relation to the conservation of global ecosystem.

Supercritical fluid application to wood preservation, (1) Principle of treatment and mechanical properties of treated wood, K. TSUNODA, M. INOUE, T. YOSHIMURA and A. ADACHI: *Proceedings of the Fouth Pacific Rim Bio-Based Composites Symposium,* Bogor, Indonesia, Nov. 2–5, 333–339 (1998).

As supercritical fluids [SCF(s)] have intermediate properties between those of gasses and liquids, it is supposed that SCFs can carry fungicides and insecticides (biocides) into porous substrates such as wood and wood-based composites under the selected levels of temperature and pressure without any cosmetic and mechanical damage. Treatment solution is prepared with SCF, and the solution is then introduced into wood and/or wood-based composites placed in the treatment chamber at or above the critical levels of pressure and temperature. Following impregnation, the pressure or temperature is decreased to recover dry treated materials. Wood specimens measuring 15 (R)×15 (T)×120 (L) mm were prepared from both heartwood and sapwood of *Cryptomeria japonica* D. Don and *Pinus densiflora* Sieb. et Zucc. and from heartwood of *Larix leptolepis* Gordon. Those were used to examine their treatability with supercritical carbon dioxide. Three treatments were conducted using carbon dioxide as a SCF and 3-iodo-2-propynyl butyl carbamate (IPBC) as a fungicide. After treatment, specimens [15 (R)×4 (T)×120 (L) mm] were cut from the original test specimens for the later bending test (span length: 100 mm). Results varied with wood species. Permeable wood species, *C. japonica* sapwood did not sustain any serious mechanical damage, while refractory species, *L. leptolepis* heartwood lost its strength possibly due to the deformation caused by pressure gradients across the transverse direction.

Supercritical fluid application to wood preservation, (2) Laboratory evaluation of decay resistance of treated wood, K. TSUNODA, T. YOSHIMURA, M. INOUE and A. ADACHI: *Proceedings of the Fourth Pacific Rim Bio-Based Composites Symposium,* Bogor, Indonesia, Nov. 2–5, 340–344 (1998).

Wood specimens measuring 15 (R)×15(T)×120 (L) mm were prepared from both heartwood and sapwood of *Cryptomeria japonica* D. Don and *Pinus densiflora* Sieb. et Zucc. and from heartwood of *Larix leptoolepis* Gordon. The specimens were treated with supercritical carbon dioxide containing 3-iodo-2-propynyl butyl carbamate (IPBC) or supercritical carbon dioxide only. Three treatments were conducted to achieve 3 levels of IPBC retentions in wood (0, lower and higher retentions) and to compare decay resistance of the treated wood samples. Six replicates were used for each treatment. The treated materials were divided into unweathered and weathered groups. The halves of them were exposed to a white-rot fungus, *Coriolus versicolor* (Linn. ex Fr.) Quel. And the remaining halves to a brown-rot fungus, *Tyromyces palustris* (Berk, et Curt.) for 12 weeks at 26±2°C in the laboratory. Thus, 9 replicates of the same treatment were served for testing. Specimens prepared from the weathered group were aged by the procedure of JIS A 9201-1991 prior to the decay test. Untreated sapwood specimens sustained more decay mass losses than heartwood specimens. Higher percent mass loss was recorded with *T. palustris*. Treatments with supercritical carbon dioxide only appeared to cause changes in decay resistance of timber samples, although the results varied with timber species. IPBC treatment definitely resulted in an enhanced decay resistance of the timber specimens. Variations of decay resistance among IPBC-treated specimens were not negligibly small. That might reflect the inconstancy of treatment by the use of supercritical carbon dioxide under the current experimental conditions.

Colony elimination of *Reticulitermes speratus* (Isoptera: Rhinotermitidae) by bait application and the effect on foraging territory, K. TSUNODA, H. MATSUOKA and T. YOSHIMURA: *J. Econ. Entomol.,* **91**(6), 1383–1386 (1998).

A natural colony of *Reticulitermes speratus* (Kolbe), the foraging population and territory of which had been estimated previously by a triple mark-recapture program at the Uji campus of Kyoto University, was used to determine the effect of bait application. Bait stations and bait tubes containing hexaflumuron were placed in the foraging territory in October, 1995 to eradicate the colony. The number of monitoring stations with foraging termites decreased after May, 1996 and no attack was observed by July, 1996. Because a later inspection in October, 1996 demonstrated no further termite attacks of monitoring stations in the foraging territory, the colony that was composed originally of >300,000 foraging termites was considered to be eliminated by bait application. Approximately 33 mg of hexaflumuron was consumed by the colony. Ten months after the end of bait application (May, 1997) some termites were present at 3 monitoring stations in the foraging territory of the eradicated colony. Reinfestation of a few more stations was found after June, 1997. Because no marked termite individuals were recaptured from any station in the foraging territory of the test colony after elimination by baitings, it was impossible to determine whether this group of termites belonged to the original colony or came from a separate colony. Our results suggest limited applicability of mark-release-recapture methodology to determine colony eradication of *R. speratus* based on the presence or absence of marked termites.

Application of borate to wood preservation, K. Tsunoda: *Mokuzai Hozon (Wood Preservation),* **25**(2), 45–58 (1999) (in Japanese).

Biocidal efficacy of borates when applied to solid wood was reviewed. Past laboratory evaluations clearly indicated that borates were effective in protecting timber from decay fungi, termites and drywood beetles as far as timber is used at covered above ground situations. No decay basidiomycetes were known to be tolerant to borates so far. These results suggested a high potential of borates in wood preservation, although a special attention should be paid to the practical application of the borate-treated products.

Termite survey in Java Island, Indonesia, T. YOSHIMURA: The Memorial Publication of the Forty Years Anniversary of Japan Termite Control Association, 155–157 (1998) (in Japanese).

The outline of termite survey in Java Island, Indonesia, conducted at January, 1997 was described with the introduction of termite researchers in Indonesia

***Coptotermes* in Indonesia,** T. YOSHIMURA, Y. TAKEMATSU, M. TAKAHASHI, S. YUSUF and P. SUKARTANA: *Proceedings of the Second International Wood Science Seminar,* Serpong, Indonesia, Nov. 6–7, 1998, B12 (1998).

As a first step to obtain the information on the biology of *Coptotermes* species in Indonesia that cause economic loss against wooden constructions, we tried to identify the pest *Coptotermes* species in West Java. Soldiers, workers and alates were collected from nine colonies which had been refereed as *C. curvignathus* before. By a comparison with the original description of *Coptotermes* species in S.E. Asia, all colonies were identified as *C. gestroi* not *C. curvignathus.* This is a new record from Indonesia, and it is possible that these species have been confused.

Detection of termite attacks by AE monitoring in urban environment, T. YOSHIMIURA, Y. FUJII and Y. IMAMURA: *Proceedings of the XIII International Congress of the International Union for the Study of Social Insects,* Adelaide, Australia, Dec. 29–Jan. 3, 1998/1999, 516(1998).

Environmental concerns have been promoting the development of alternative termite-controlling methods with less use of chemicals. Recently some trials were made in wooden houses for detection of termite attacks by AE (acoustic emission) monitoring and treatment with a small amount of chemicals in urban environment in Japan. Piezoelectric sensors with a resonance frequency of 150 kHz were attached on the surface of wooden construction members in three houses. Termite activity was evaluated by numbers of AEs counted for a fixed period.

Deterioration of houses and its control, T. YOSHIMURA: *J. Jpn. Res. Assoc. Tex. End-uses,* **40**(1), 12–18 (1999) (in Japanese).

There are many agents that deteriorate houses. In this review, the agents were classified into physical, chemical, mechanical and biological problems, and were then described for their characteristics. Among biological deterioration being caused mainly by insects and microorganisms, termite attack is likely to be the most important one. Following the general description of termite, a new trend in termite controlling procedures is introduced.

Enhancement of biological and physical properties of wood by boric acid-vinyl monomer combination treatment, M.K. YALINKILIC, K. TSUNODA, M. TAKAHASHI, E.D. GEZER, W. DWIANTO and H. NEMOTO: *Holzforschung,* **52**(6), 667–672 (1998).

Boron treatment was combined with vinyl polymerization to improve leaching resistance of boron from wood, as well as dimensional stability, biological and fire resistance of wood. Boric acid (BA) was impregnated into wood specimens [sapwood of *Cryptomeria japonica* D. Don, 20 (*T*)×20 (*R*)×10 (*L*) mm] as 1% aqueous solution prior to vinyl monomer treatment. Styrene (ST), methylmethacrylate (MMA) and their mixture (50 : 50, v/v) were impregnated in the presence of catalyst and a crosslinker. Polymerization was conducted by heat radiation method at 90°C for 4 hours. Treated specimens were then subjected to decay and termite tests, as well as oxygen index (O.I.) determination. Anti-swelling efficiency (ASE) and water absorption levels (WA) were also measured by standardized methods. Vinyl monomer succeeded in reducing WA of wood to a minimum level and delay boron leaching considerably. The treated wood proved to be resistant against two decay fungi, *Tyromyces palustris* and *Coriolus versicolor* and very destructive termite, *Coptotermes formosanus* even after ten severe weathering cycles. BA increased O.I. levels of monomer-treated wood, which resulted in a lower flame spread index. Moreover, BA suppressed the smoke generation due to monomer cooperation in wood.

Effective use of boron compounds in preservation of wood and wood-based composite materials, M.K. YALINKILIC, Y. IMAMURA, K. TSUNODA and M. TAKAHASHI: *Proceedings of the Second International Wood Science Seminar,* Serpong, Indonesia, Nov. 6–7, B14 (1998).

Boron compounds are useful in wood preservation owing to their environmentally safe characteristics and relatively low costs in addition to their well-known high bioactive and fire resistant properties. Despite their unique properties, however, these compounds are readily leachable from treated wood under humid conditions. Therefore, they are of limited market value for exterior applications. To achieve a long-lasting boron effect in wood, one practical approach is the chemical complexion of boron with a fixing agent capable of forming water insoluble complexes upon dehydration in wood. However, it reduces the efficacy against wood decay fungi. The latest researches have, therefore, been directed to partial fixation systems of boron in wood while conserving sufficient mobility to maintain preservative action. Extensive studies, similarly, have been conducted on effective use of boron compounds in preservation of wood and wood based composite materials in WRI, Kyoto University since 1995. Supplementary treatments of boron pretreated wood with vapor phase formalization or vinyl monomers: styrene and methylmethacrylate, or addition to a compatible chemical such as, melamine formaldehyde, non- or low-formaldehyde agents or trimethylol melamine, were applied to extend the service life of boron-treated wood. Among them boron addition to trimethylol melamine or a secondary treatment of boron treated wood with vinyl monomers are found promising for the future work. Lately, it has been realized that re-crystallization of boric acid under certain conditions to yield trimeric hydroxyborate ion or obtaining the metaboric acid ester from dehydrated oxide forms of boric acid can be a potential new possibilities to develop stable boron treatments in preservation practices.

Effect of post hot-compression of boron-treated wood at radial direction on boron leachability, M.K. YALINKILIC, K. TSUNODA, W. DWIANTO, M. INOUE, F. TANAKA and M. TAKAHASHI: *Proceedings of the Second International Wood Science Seminar,* Serpong, Indonesia, Nov. 6–7, C69–79 (1998).

Post hot-compression treatment was applied to improve

the leaching resistance of boron from the borate-treated wood. Sapwood specimens of *Cryptomeria japonica* D. Don [20 (tangential)×20 (radial)×10 (longitudinal) mm] which were first impregnated with borates [boric acid (BA) and phenylboronic acid (PBA)] were compressed by radial hot-pressing at 171, 180 and 200°C with or without steaming. Following 10 cycles of wet/dry weathering, amount of boron leached from borate-impregnated and hot-compressed wood was measured by ion chromatograph. Degrees of crystallinity of BA-treated wood and BA itself were determined by X-ray diffractometry. Both boron compounds did not cause any unfavorable effect on the setting of the compressed wood materials. Although compression process did not seem to improve boron immobility in wood, compression under high steam pressure in a close system (CS) resulted in a drastic reduction in borate ion concentration of the leachates. Two potential reaction mechanisms appear to account for the results: a) formation of trimeric hydroxyborate ion, and b) esterification of oxide forms of boron with the water molecules supplied by vaporized water in the CS.

Boron effect on decay resistance of some fire-retardant coatings applied on plywood surface, M.K. YALINKILIC, W.-Y. SU, Y. IMAMURA, M. TAKAHASHI, Z. DEMIRCI and A.C. YALINKILIC: *Holz Roh. Werkst.*, **56**(5), 347–353 (1998).

Boron effect on decay resistance of some fire-retardant coatings applied on plywood surface was studied. Boric acid (B) was mixed into aqueous trimethylol melamine (TM) solution to increase the fixation in wood. To reveal the decay resistance of boric acid-added formulations, coatings were applied over Radiata pine plywood surface as 100 g/m^2 amounts. Phosphoric acid (P) and dicyandiamide (D) were also used alone or in mixtures as reference coatings for comparison. Coated specimens were exposed to weathering according to Japanese Industrial Standard JIS A 9201 (1992) as severe leaching for 10 cycles, prior to decay test. Non-leached and leached specimens, then, were inoculated with a brown-rot fungus *Tyromyces palustris* and a white-rot fungus *Coriolus versicolor*. Extent of the fungal attack was determined by mass loss of the specimens after 12 weeks incubation and microscopic examinations by 6x magnification. Results indicated that TMB and TMDB coatings imparted the panels complete decay resistance despite after severe weathering conditions and were proved superior over all other single and mixture coatings. Although other combinations and sole treatments used in the study were also effective to inhibit the fungal damage before weathering, leaching greatly reduced their protective efficacy. Surface characteristics of decayed specimens were consistent with the determined values of mass losses caused by fungal attack. TMB and TMDB coatings were remarkably effective in maintaining sound surface properties after exposure to weathering and decay fungi.

Effect of boron addition to adhesive and/or to surface coating on fire retardant properties of particleboard, M.K. YALINKILIC, Y. IMAMURA, M. TAKAHASHI and Z. DEMIRCI: *Wood Fiber Sci.*, **30**(4), 348–359 (1998).

Boron added to urea formaldehyde (UF) resin during manufacture of board from waste tea leaves was combined with a fire-retardant coating system containing boron to further reduce combustibility. Boric acid (BA) and borax (BX) were used as boron compounds separately or in a mixture of 5 : 1 (BA : BX, w/w) in aqueous solutions of UF resin. BA+BX mixture was also added to 40% aqueous solution of trimethylolmelamine (TMM) (as a binding agent) and applied to the board surface. Fire retardant properties were determined according to the Japanese Industrial Standard JIS A 1322. Thickness swelling and water absorption levels were not changed remarkably by boron addition to UF resin while static bending and internal bond strengths were reduced to some extent. However, BX addition suppressed the adverse effect of BA on board strength probably by buffering its acidic pH to almost neutral levels while BA reduced the glowing or smoldering effect of BX. Panels with or without added boron showed no ignition after cutting off the flame source after 13 min. Surface coating with the boron-added TMM improved fire retardance. To limit the reduction of strength properties due to boron addition to the resin, fire-retardant surface coating can be applied to impart a required level of fire protection.

Biological, physical and mechanical properties of particleboard manufactured from waste tea leaves, M.K. YALINKILIC, Y. IMAMURA, M. TAKAHASHI, H. KALAYCIOGLU, G. NEMLI, Z. DEMIRCI and T. OZDEMIR: *Int. Biodeterior. Biodegrad.*, **41**(1), 75–84 (1998).

Environmental questions have arisen from the use of chemicals in wood or bio-based composite to stop biodeterioration. As a consequence, various environmentally friendly treatments or naturally durable plant species are now being evaluated. We believed the high phenolic extractive content of tea leaves, and their abundance as residual waste at tea producing factories warranted studies on the utilization of these wastes in particleboard manufacture. Waste tea leaves particleboard (WTLB) is expected to be more resistant against biological agents owing to high phenolic extractive content. Mass loss of WTLB, the edges of which had been sealed with an epoxy, was 3.5–8.6% and 6.0–12.1% for paraffin-added and non-added specimens, following degradation by *Tyromyces palustris* and *Coriolus versicolor*, respectively. The addition of paraffin to binder UF resin during the manufacturing of the board and the sealing the edges of specimens before decay testing kept degradation to a minimum. In reference materials reported previously, WTLB proved resistant to decay-type fungi. Mass loss of WTLB after exposure to Formosan subterranean termite *Coptotermes formosanus* was around 16%. However, termite mortality levels and trends over the three weeks of termite attack suggest that phenolic extractives of tea leaf act as natural toxicants that gradually but steadily increase mortality particularly from the third week of exposure. Tested physical and mechanical properties of WTL.B indicated that it performs as well as the general purpose boards designated in BS 5669.

FT-IR studies of the effects of outdoor exposure on varnish coated wood pretreated with CCB, M.K.

YALINKILIC, R. ILHAN, Y. IMAMURA, M. TAKAHASHI, Z. DEMIRCI and A.C. YALINKILIC: *Proceedings of the Fourth Pacific Rim Bio-Based Composites Symposium,* Bogor, Indonesia, November 2–5, 345–357 (1998).

Scots pine (*Pinus sylvestris* L.) and chestnut (*Castanea sativa* Mill.) {10 (*R*)×100 (*T*)×150 (*L*) mm} were coated with a polyurethane and an alkyd based synthetic varnishes. Some of the panels were treated with CCB (chromium-copper-boron) or varnishes themselves before coating, as preservative-coating or water repellent (WR)-coating combinations, respectively. Outdoor performances of coatings over treated and untreated wood surface were investigated by FT-IR analysis in order to evaluate chemical changes in lignin on the exposed surfaces of the panels beneath film layer. Outdoor exposure was performed in Black Sea Region of Northern Turkey where humid weather is dominant throughout year that usually accelerates early failures of coatings. Tangential surfaces of wood panels were exposed to 45° vertical angle to the ground. Frames that hold the test panels were set to sun rising direction. Results of the first six months of the weathering indicated that synthetic varnish coating over untreated wood or over CCB-treated wood limited the reactions in lignin on wood surface when compared with polyurethane coating. Chromium in CCB, however, did not show remarkable effect on the chemical changes of wood surface for the tested periods of time. Alone coating with varnishes were generally more appropriate than combination coatings in this respect, referring to the results of IR spectral analysis.

Weathering effects on surface quality of CCB treated wood coated with clear varnishes, M.K. YALINKILIC, R. ILHAN, Y. IMAMURA, M. TAKAHASHI, Z. DEMIRCI and A.C. YALINKILIC: *Proceeding of the Fourth Pacific-Rim Bio-Based Composites Symposium,* Bogor, Indonesia, November 2–5, 366–376 (1998).

Outdoor performances of a polyurethane varnish and an alkyd based synthetic varnish coated over CCB (chromium-copper-boron)-treated Scots pine (*Pinus sylvestris* L.) and chestnut (*Castanea sativa* Mill.) {10 (*R*)× 100 (*T*)×150 (*L*) mm} surface were investigated. These varnishes were also applied on wood surface as sole coatings or impregnated into wood as water repellent (WR) solutions. Outdoor exposure was performed in Black Sea Region of northern Turkey where humid weather is dominant throughout year that accelerates early decomposition of coated wood surfaces. Wood panels were inserted on frames by 45o vertical angle to the ground at an open field. Tangential surfaces were arranged to sun rising direction. After three and six months of exposure, color and brightness changes, adhesion of coating layer to wood surface, water absorption through coating layers, mass loss and hardness of board surface were studies. CCB-pretreatment of clear varnish-coated wood resulted in significant color stability. Color changes (ΔE) realized at remarkably lower levels for Scots pine panels coated with synthetic varnish after CCB-treatment. WR impregnation of wood with the varnishes prior to coating imparted both wood species considerable color stability. Some adhesion loss were detected between varnish layers and CCB-pretreated surfaces after 6 months of exposure. But water absorption through coated surface did not change significantly. Treated wood surface became harder by time at outdoor exposure while untreated surface softened. Polyurethane varnish yielded harder surface than synthetic varnish. But hardness increase on the surfaces coated with the synthetic varnish was more drastic upon exposure to weathering. Mass losses of wood panels were negligible after 6 months of exposure for all treatments compared with untreated control and no visible damage was occurred on the coated surfaces.

A new process for in situ polymerization of vinyl monomers in wood to delay boron leaching, M.K. YALINKILIC, W. DWIANTO, Y. IMAMURA and M. TAKAHASHI: *The International Research Group on Wood Preservation,* Document No. IRG/WP 98-40110, 16 pp. (1998).

Efforts were accelerated on effective use of boron compounds in wood preservation owing to their environmentally safe characteristics and relatively low costs in addition to their well-known high bioactivity and fire resistant properties. Although having these unique favorable properties, they are readily leachable from treated wood at humid conditions. Therefore, they had limited market for exterior applications. A supplementary combination treatment with vinyl monomers; styrene (ST) and methylmethacrylate (MMA) was studied in order to extend the service life of boron treated wood. Sapwood specimens of Japanese cedar (*Cryptomeria japonica* D. Don) first treated with boric acid (BA) at 1.00% aqueous solution concentration. Vinyl monomers were impregnated after air-drying of BA-treated wood at ambient temperatures. Polymerization was performed during compression of monomer impregnated wood to a 50 to 70% dry set of radial dimension under a hot-press heated to the polymerization temperatures of 60 and 90°C required by the selected catalyst VAZO (α, α'-Azobis-isobutyronitrile) and benzoyl peroxide, respectively. Wood acquired a perfect dimensional stability and remarkably high moisture exclusion efficiency with the minimum water holding capacity with the compressed-wood polymer composite (CWPC) process that was approved by submerging of the test specimens in tap water, boiling water exposure to a 10 cycles accelerated severe weathering. As a result, boron leaching rate from CWPC pretreated with BA was considerably slower than that from ordinary WPC. Scanning electron microscope (SEM) observations were found explanatory for controlled-but-continuous boron leaching determined analytically. An effective bulking was found necessary to accompany to polymerization in cell wall with an even distribution of monomer in wood. Grafting to cell wall components can be tried further to achieve an envelop polymerization of boron deposited sites in WPC for better boron immobility.

Biological resistance of stem-compressed wood pretreated with borates, M.K. YALINKILIC, W. DWIANTO, Y. IMAMURA, K. TSUNODA and M. TAKAHASHI: *The International Research Group on Wood Preservation,* Document No. IRG/WP 99-30190, 11 pp. (1999).

Wood compression under heating is aimed to enhance

dimensional stability and surface hardness. Preservative treatment with an appropriate chemical is additionally required for the protection of wood against biological agents under hazardous service conditions. Boron pretreatment of compressed wood was targeted to a mutual benefit of increasing biological resistance of compressed wood as boron was converted to a more stable form through hydration and dehydration reactions under steaming at elevated temperatures in a closed system. Accordingly, boric acid (BA) (at 0.25, 1.00 and 4.70% aqueous concentration)- or phenylboronic acid (PBA) (at 0.34, 0.50, 1.00 and 2.00% aqueous concentration)-impregnated Japanese cedar (*Cryptomeria japonica* D. Don) specimens were compressed at their radial direction to 50% dry set at 171, 180 and 200°C. The compressed specimens were subjected to decay and termite tests following exposure to a severe ten-cycle wet/dry processes according to Japanese Industrial Standard JIS K 1571 (1998). BA pretreated-compressed wood exhibited remarkable resistance against a white-rot fungus, *Trametes versicolor*, but not so effective against a brown-rot test fungus, *Fomitopsis palustris* even at high boron loads which resulted in a high termite resistance. PBA pretreatment appeared to be very effective against both decay fungi and Formosan subterranean termite when wood specimens were compressed at high temperatures and steam pressure.

***In situ* polymerization of vinyl monomers during compressive deformation of boric acid treated wood to delay boron leaching.** M.K. YALINKILIC, Y. IMAMURA, M. TAKAHASHI and A.C. YALINKILIC : *Forest Prod. J.*, **49**(2), 43–51 (1999).

Boron compounds are useful in wood preservation owing to their environmentally safe characteristics and relatively low costs in addition to their well-known high bioactive and fire resistant properties. Despite their unique properties, however, these compounds are readily leachable from treated wood under humid conditions. Therefore, they are of limited market value for exterior applications. A supplementary treatment with vinyl monomers ; styrene and methyl methacrylate, was applied to extend the service life of boron-treated wood. Sapwood specimens of Japanese cedar (*Cryptomeria japonica* D. Don) were first treated with boric acid (BA) at 1.00% aqueous solution concentration, then after air-drying at ambient temperatures, impregnated with vinyl monomers. Polymerization was performed during radial compression of monomer impregnated wood to a 50 to 70% dry set dimension under a hot-press heated to the polymerization temperatures of 60 and 90°C required by the selected catalysts VAZO (α, α'-Azobis-isobutyronitrile) and benzoyl peroxide, respectively. The wood acquired perfect dimensional stability and remarkably high moisture exclusion efficiency with minimum water holding capacity following compressed-wood polymer composite (CWPC) processing as determined by submerging test specimens in tap water, boiling water, and exposing them to 10 cycles of accelerated severe weathering. As a result, the rate of boron leaching from CWPC pretreated with BA was considerably slower than that from WPC. Scanning electron microscope observations suggested how controlled-but-continuous boron leaching might have occurred. An "enveloping" treatment of boron deposited in cell walls by an effective bulking process was found essential for better immobility.

Biological, mechanical and thermal properties of compressed wood polymer composite (CWPC) pretreated with boric acid, M.K. YALINKILIC, Y. IMAMURA, M. TAKAHASHI, Z. DEMIRCI and A.C. YALINKILIC : *Wood Fiber Sci.*, **31**(2), 151–163 (1999).

Compressed-wood polymer composite (CWPC) was prepared by *in situ* polymerization of vinyl monomers, styrene (ST), methylmethacrylate (MMA) and their combination (50 : 50, v/v) under hot-compression of treated sapwood of Japanese cedar (*Cryptomeria japonica* D. Don.) to a dry set of 50 and 70% of original radial dimension. Boric acid (BA) was impregnated into wood at 1.00% aqueous solution concentration prior to monomer treatment. CWPC with and without BA pretreatment was tested in terms of biological resistance and, mechanical and thermal properties. BA pretreatment imparted CWPC total resistance against decay test fungi *Tyromyces palustris* and *Coriolus versicolor*, representing brown- and white-rot fungi, respectively. CWPC showed remarkable resistance against Formosan subterranean termite *Coptotermes formosanus* and BA pretreatment contributed to a total inactivation of termite activity. Surface hardness of CWPC was superior to WPC obtained at the same polymerization temperature and time by a conventional heat process in an oven without compression. Modulus of elasticity and rupture were also considerably improved with this newly introduced *in situ* polymerization process suggesting the great potential of CWPC for exterior use. Thermal analysis revealed a reducing effect of boron on heat release of CWPC during combustion.

Discoloration of imported North American woods by sap-stain fungus, *Graphium* sp. and its prevention, H. KUMAGAI and K. TSUNODA : *Mokuzai Gakkaishi*, **45**(2), 164–170 (1999) (in Japanese with English summary).

Anti-sapstain treatments of imported North American timber species such as Douglas fir (*Pseudotsuga menziesii* Franco) and western hemlock (*Tsuga heterophylla* Sarg.), that account for approximately 40% of the total wood supply in Japan, are very important in reducing economic losses caused by sapstaining fungi and molds. In the summer season of 1993, unfortunately, a serious microbial growth was found on sawn products treated with a formulation containing 3-iod0-2-propunyl butyl carbamate (IPBC) and 4, 5-dichloro-2-*n*-octyl-4-sothiazolin-3-one (DCOI) at asawmill in Japan. The isolated microorganisms involved in the microbial infection was an asexual stage of *Ceratocystis* sp. that is well known as blue-stainer of softwood species, *Graphium* sp. Following confirming the generation of discoloration caused by the isolate in the laboratory, the isolate was used for JWPA testings to evaluate the effectiveness of anti-sapstain formulations. All of the formulations tested proved effective in the tests. A newly-designed pre-incubation method in which treated wood specimens were placed on the wood pieces with well grown test fungus on them demonstrated that two formulations containing methylene bisthiocyanate (MBT) were effective, and a practically

used formulation of IPBC and DCOI was ineffective. Results of the field evaluation were similar to those of laboratory evaluation. As the results obtained using the pre-incubation method proved to be available as measure to screen chemicals for protecting lumber from sapstain fungi at sawmills. A new anti-sapstain formulation consisting of IPBC, DCOI, and MBT was developed through a series of current investigations. Further investigations on the mode of action of chemicals are needed to understand the differences in efficacy among formulations in connection with test methods.

Attraction of steamed Japanese larch (*Larix leptolepis* (Sieb. et Zucc.) Gord) heartwood to the subterranean termite *Coptotermes formosanus* Shiraki (Isoptera : Rhinotermitidae), S. Doi, M. Takahashi, T. Yoshimura, M. Kubota and A. Adachi : *Holzforschung,* **52,** 7–12 (1998).

The attraction of steamed Japanese larch (*Larix leptolepis* (Sieb. et Zucc.) Gord.) heartwood to the subterranean termite *Coptotermes formosanus* Shiraki was investigated with choice tests and no-choice tests. Wood samples were prepared from green larch boards steamed at 170°C for 30–240 min. In a choice test and a no-choice test, weight losses due to the termite attack were very small in non-steamed samples while they were large in steamed ones. Steamed samples extracted with hot water were not attacked by termite in a choice test. Japanese cedar (*Cryptomeria japonica* D. Don) wood specimens treated with water soluble fractions from the hot water extractives of larch were preferably attacked in a choice test. These phenomena suggest that steaming produces attractants and degrades, removes and/or modifies some larch wood constituents which suppress the termite attack.

Biological properties of glue-line treated plywoods, S. Yusuf, M.K. Yalinkilic, Y. Imamura, S. Fushiki, T. Saito and Y. Katsuzawa : *Proceedings of the Fourth Pacific Rim Bio-Based Composites Symposium,* Bogor, Indonesia, November 2–5, 124–132 (1998).

To improve the decay and termite resistance of plywoods, specimens of tropical species red-meranti (*Shorea* spp.) were prepared as raw materials, and were then treated by the addition of insecticides and fungicides to the glue. The biological properties of untreated and treated plywoods were evaluated by laboratory tests as well as field-exposure tests.

The results obtained indicated that the treated plywoods effectively resisted attacks by *Coptotermes formosanus* when the active ingredient (a.i.) imidachloprid at 1,400 kg/m^3 was added, especially compared with untreated plywood. Treated lauan plywoods with IF-1000 and IPBC were able to effectively inhibit the potential decay caused by both *Tyromyces palustris* and *Coriolus versicolor.*

Weathering properties of phenolic-resin treated particleboards from fast-growing woods and agrowastes, S. Yusuf, Y. Sudiyani, H. Kajita, Y. Imamura and M. Takahashi : *Proceedings of the Second International Wood Science Seminar,* Serpong, Indonesia, Nov. 6–7, C92–100 (1998).

Particleboards were treated with phenolic resin and their biological and physical properties were evaluated before and after weathering. The particles were sprayed with a mixture of a low molecular-weight phenol-formaldehyde resin and the adhesive resin. The biological and physical properties of the treated particleboards were affected considerably by the incorporated resin loading. Results obtained from accelerated laboratory tests of biodegradation suggested that the incorporated resin solids worked well to enhance the decay and termite resistances of particleboards. The internal bond strength, modulus of rupture and modulus of elasticity increased with increasing of resin loading. After exposure to natural weathering, the properties decreased gradually due to the effect of sunshine or rainwater, however, the treated particleboards maintained the improved strengths and biological resistances.

Improvement of weathering properties of particleboards by addition of low molecular weight phenolic resin to glue adhesive, Y. Sudiyani, Y. Imamura, M. Takahashi, S. Yusuf and H. Kajita : *Proceedings of the Fourth Pacific Rim Bio-Based Composites Symposium,* Bogor, Indonesia, Nov. 2–5, 358–365 (1998).

Phenol-resin treated particleboards were prepared from the flake-type particles of radiata pine (*Pinus radiata*), using PF resin mixture of low molecular weight resin and the conventional adhesive-type resin with high molecular weight. The target levels of resin loading were 5%, 7.5% and 10%. The boards were exposed to outdoor weathering at PUSPITEK Serpong, Tangerang, Indonesia, for 6 and 12 months. Modulus of rupture (MOR), modulus of elasticity (MOE) and internal bond strength (IB) of the specimens were determined during the period of exposure. The biological resistances of these specimens after weathering were also evaluated by decay tests using *Tyromyces palustris* and *Coriolus versicolor* and by termite test using *Coptotermes formosanus.* The results indicated that untreated particleboards showed the poorest performance, losing more that 40 percent of initial MOE and MOR after 12 months. Decay test revealed that after weathering exposure for 12 months the PF resin treated particleboard with RL of 7.5% and 10% were sufficiently resistant to *T. palustris* and *C. versicolor.* However the PF treated particleboards hardly inhibited the attacks by *C. formosanus* after 12 months of outdoor exposure.

Weathering properties of phenolic-resin treated wood, Y. Sudiyani, Y. Imamura and M. Takahashi : *Proceedings of the Second International Wood Science Seminar,* Serpong, Indonesia, Nov. 6–7, C101–111 (1998).

The effect of low molecular weight of phenol-formaldehyde (PF)-resin (Mn : 344) on the weathering resistance of wood was studied. Hardwood of albizia (*Paraserianthes falcata* Becker.) and softwood of sugi (*Cryptomeria japonica* D.Don) with 145 (*L*)×45 (*T*)×3 (*R*) mm in size were subjected to PF-resin treatment and then exposed to natural weathering for 1 year, and to artificial weathering for 1,080 h. Evaluation of weathering properties was carried out by surface performance, color difference and decay resistance. The results showed that PF-resin treatment improved the surface resistance of wood such as color stability and physical performance in

cracking and hangnail after weathering. Even though the decay resistances of the treated wood against the brown and white rot fungi were reduced by exposure to weathering, weight loss due to fungal attacks were significantly small comparing with untreated wood. PF-resin treatment of sugi wood was found to be much more effective than albizia wood in improving the physical properties and decay resistance after weathering.

Effectiveness of insecticide and fungicide addition to a strong alkaline adhesive on termite resistance of plywood, S. FUSHIKI, T. SAITO, Y. KATUZAWA, M.K. YALINKILIC and Y. IMAMURA: *The International Research Group on Wood Preservation,* IRG Poster, Presented at 29th Annual Meeting, 14–19 June, Maastricht, Holland, 10 pp. (1998).

When producing the preservative-treated plywood by glue-additive method, protective efficacy of the chemicals is greatly influenced by mixing them with adhesives and then hot-pressing at a curing temperature. Pine plywood was treated with the insecticides and fungicides added to strong alkaline adhesive of phenol-formaldehyde resin (pH=10–13), which is commonly used for wood-based materials. Treated plywood with the mixed chemicals of chlorpyrifos and IF-1000 effectively resisted to the attack by Formosan subterranean termite *Coptotermes formosanus* Shiraki. The mixed chemicals of imidacloprid or bifenthrin with the IPBC also showed great effectiveness against termite attacks at laboratory tests and followed field exposure trials.

Estimation of preservative toxic threshold retention from laboratory decay tests: a new method, E.D. GEZER, M.K. YALINKILIC, K. KIZILKAYA and J.H. MICHAEL: *Wood Sci. and Tech.,* **33**(1), 63–71 (1999).

This research illustrates a new procedure of analyzing data from soil- or agar-block decay tests using non-linear regression techniques to estimate a toxic threshold retention point for wood preservative chemicals. The model can be used to provide an objective estimate of the level of retention that is fully adequate, and can be applied satisfactorily to decay data from laboratory tests. This so-called broken line model procedure analyzes the decay data simultaneously by separating it into two different parts according to the threshold retention point. Such a procedure is preferable to previous methods the suffer from the need of transforming decay data. Our analysis can be performed in any statistical analysis package that includes a non-linear regression procedure, regardless of having a small or large data set, under the assumption that residuals are normally distributed with a homogeneous variance. The method of estimating weight loss due to decay and the one due to operational procedure are also described.

Distribution of polymers in cell walls and their effect on the decay resistance of wood-plastic composites, Y. IMAMURA, M. TAKAHASHI, J.Y. RYU and H. KAJITA: *Biocontrol Sci.,* **3**(2), 109–112 (1998).

The biological resistance of wood plastic composites using methyl-methacrylate and phenolic-resin was evaluated with an emphasis on the structural characteristics of the cell wall after exposure to fungal attack. Difference in the polymer deposition in the wood cellular structure due to combination with plastic exhibited the specific patterns of cell wall erosion caused by decay fungi. Scanning electron microscopic observations confirmed that the small-molecular weight phenol-formaldehyde (PF) resin easily penetrated the wood and led to the deposit of polymers within the cell walls, resulting in a high resistance to decay. In contrast, the limited levels of penetration of the large-molecular weight PF-resin and the methacrylate resin led to formation of polymer bodies in the cell lumens or the partial surface coatings which contributed little to the decay resistance.

Weatherability of exterior wood coatings in Japan, M. KIGUCHI, M. SUZUKI and Y. IMAMURA: *Advances in Exterior Wood Coatings and CEN Standardization* (1998).

The weather resistance of eleven commercial exterior wood coatings was assessed using natural and artificial accelerated (sunshine carbon-arc) weathering trials. The color, water repellency, glossiness and extent of surface defects in finishes were evaluated before and after the weathering tests. The main defects that developed in the film forming coatings were cracks and delamination of the films. In contrast, the penetrating stains showed discoloration due to loss of pigmentation and the accumulation of atmospheric particulate pollutants. A questionnaire was developed that asked respondents to comments on the refinishing requirements for exterior coatings exposed to natural and accelerated weathering. Results suggested that refinishing of film forming coatings and penetrating stains exposed to accelerated weathering was required after 1,500–2,000 hours and 1,000–1,500 hours, respectively. Refinishing of film forming coatings and penetrating stains exposed to natural weathering was required after 12–24 months and 6–12 months, respectively. From the results of the exposed trial (above) and the questionnaire, a rating scale to assess the loss in properties of exterior coatings during natural and accelerated weathering was developed.

Combinations of wood and silicate Part 6. Biological resistances of wood-mineral composites using water glass-boron compound system, T. FURUNO and Y. IMAMURA: *Wood Sci. Technol.,* **32**, 161–170 (1998).

Wood-mineral composites were made by introducing inorganic substances into wood using the water glass (sodium silicate)-boron compound system (double treatment). Composites were also prepared with boron compounds alone (single treatment), and biological resistances of the two types of composites were evaluated and compared. After the leaching procedure, the composites using the water glass-boron compound system showed generally excellent termite resistances with the negligible weight losses of specimens and high mortalities of workers and soldiers. On the contrary, the single treatment and the double treatment using the reactants of non-boron compounds showed the slight or little resistances against termite attacks, accounting for the high leachability of the inorganic substances formed in wood and/or low effectiveness of the chemicals. Also, the water glass-boron compound system was found to enhance greatly the decay resistances if water-soluble inorganic

substances were fully removed out from the specimens. The formation of insoluble inorganic substances in the water glass-boron compound system proved to contribute much to the enhancement of biological resistances.

Some properties of wood-mineral composites using the colloidal silica solution system—Termite resistance, photo stability, hardness and abrasion resistance—, T. FURUNO, Y. IMAMURA, O. ASADA and S. KATOH : *J. Soc. Mat. Sci.,* **48**(3), 245–250 (1999) (in Japanese with English summary).

Following the previous paper treating with the production and properties of wood-mineral composites using the colloidal silica solution system, we investigated termite resistance, photo stability, hardness, and abrasion resistance of composites. The composites were prepared by the same process previously reported using a colloidal silica solution and sapwood and heartwood of sugi (*Cryptomeria japonica* D. Don). The composites made by using the colloidal silica-boric acid system showed an excellent termite resistance with the negligible weight losses of specimens and 100% mortalities of workers and soldiers, and the metal compounds (Cu, Ag, and Ti)-added system had a certain extent of resistance against termite attack. As a result of photo stability test with ultraviolet (UV) light, the changes in color difference in the radial section of the composites irradiated with UV light were smaller than those of the untreated wood, particularly the smallest change for the titanium dioxide added system, showing the enhancement of photo stability. The composites remained photo proof even after leaching. The brightness in the cross section changed greatly in the boric acid- and titanium dioxide-added system compared with the untreated wood. The Brinell hardness in the cross section showed an increase up to 70% compared with the untreated wood, and it increased with an increase in weight percent gain (WPG). This hardness held an increase up to 22% compared with the untreated wood even after leaching and the hardness in the radial section increased up to 30%, revealing little reduction of hardness in any case. The Taber type abrasion index in the tangential section tended to increase with an increase in WPG. This result showed the reduction of abrasion resistance.

Modification of wood by treatment with low molecular phenol-formaldehyde resin, T. FURUNO, Y. IMAMURA and H. KAJITA : *Proceedings of the 4th Pacific Rim Bio-Based Composites Symposium,* 295–304 (1998).

The penetration of phenol-formaldehyde resin into wood cell walls was investigated by means of light microscopy, scanning electron microscopy (SEM), and electron prove X-ray microanalysis (EPMA). Three kinds of *m*-bromophenol-formaldehyde resins having number average molecular-weights (Mn) of 290, 470, and 820 were used to detect the presence of resin as a signal of bromine (Br). In the specimens impregnated with the small molecular-weight resin (Mn ; 290) at concentrations of 1% to 15%, light microscopic observation revealed that the phenol resin was hardly located in tracheid lumina at lower concentrations. Even at a concentration of 15%, the number of tracheids filling the resin in their lumina was very small. From secondary electron and Br-X ray images in EPMA, the presence of phenol resin in tracheid walls was found even at a concentration of 1%. The presence of resin was evident at concentrations of more than 3%, indicating the distribution of resin in the whole thick walls of late wood tracheids. In conclusion, the phenol resin with small and middle molecular-weights (Mn ; 290 and 470) proved to penetrate mostly into the cell walls, contributing to the enhancement of dimensional stability in resin-impregnated wood. Also, for phenol resin with a large molecular-weight (Mn ; 820), the resin components with the smaller molecular-weight were suggested to be present in the walls, having little contribution to the dimensional stability.

Properties enhancement of wood by treatment with neutralized phenolic-resin, Y. IMAMURA, M.K. YALINKILIC, H. KAJITA and T. FURUNO : *Proceedings of the 4th Pacific Rim Bio-Based Composites Symposium,* 48–54 (1998).

To enhance the dimensional stability and the biological properties, the low-molecular weight phenolic resins of conventional alkaline type (pH : 10.3) and neutralized type (pH : 6.5) were impregnated into Japanese cedar wood (*Cryptomeria japonica* D. Don) and heat-cured. The treatment with the alkaline-type resin changed the color of wood to red-brown, however, the neutralized one retained the original wood color. The concentrations of the resin solutions and the weight gains of wood after treatment were highly correlated, and the target weight gain could be assessed from the solution concentration. High dimensional stability at 60% of anti-swelling efficiency was attained when both types of resins were impregnated at about 30% weight gain, and no significant difference was recognized between them. To suppress the decay attacks by the brown-rot fungus and the white-rot fungus, 15% and 10% weight gains due to resin treatment was required for the neutralized and alkaline- types of phenolic resins, respectively. The weight reduction of treated wood after the leaching test of ten-cycles of wet and dry was negligible for the alkaline-type resin, and 2 to 5% for the neutralized phenolic resin.

Detection of AE generated by the feeding activity of termites using PVDF (polyvinylidene fluoride) film, Y. YANASE, Y. FUJII, S. OKUMURA, Y. IMAMURA and T. YOSHIMURA : *For. Prod. J.,* **48**(7/8), 43–46 (1998).

Polyvinylidene fluoride (PVDF) film is the most sensitive piezo-electric polymer. Acoustic emission (AE) monitoring using 40-μm-thick PVDF film was used for the nondestructive detection of termite attack in wood. The frequency spectra of AEs detected by PVDF film had some peaks under 10 kHz, which depended on the characteristic frequencies of the longitudinal vibration of the specimen. Although the sensitivity of 1-ply PVDF sensor was lower than the of a PZT sensor, the sensitivity of a PVDF sensor could be increased by using multiple sheets. These results suggest that it is feasible to use PVDF film mounted in the wall of a house as an AE sensor to detect termite activity.

Acoustic emission (AE) detected from wood attacked by powder-post beetles, *Lyctus brunneus*

Stephens, Y. IMAMURA, A. ADACHI and Y. FUJII : *Jpn. J. Environ. Entomol. Zool.,* **9**(3), 98–100 (1998) (in Japanese with English summary).

Acoustic emission (AE) of the burst type was detected from the air-dried sapwood of *Parashorea* sp., which were inoculated with larvae of the powder-post beetle, *Lyctus brunneus* Stephens. Piezoelectric sensors of resonant frequency of 150 kHz were attached to the specimen. More AEs were detected from the specimens with more larvae inoculated. AE generation stopped upon tapping the specimen with a finger, and started again in one to 24 hours after the tapping was stopped. The three phases of the AE generation were confirmed, the first term up to 200 hours when the AE events increased rapidly, the second one up to 500 hours of less increasing of AEs and the last 100 hours of rapid increase, respectively. These phases could be associated with the growing stages of larvae, pupae, and adults, respectively.

Detection of termite attack in wooden buildings with AE monitoring: Case study at a traditional Japanese warehouse, Y. FUJII, Y. YANASE, Y. IMAMURA, S. OKUMURA and S. OKA : *Jpn. J. Environ. Entomol. Zool.,* **9**(3), 101–105 (1998) (in Japanese with English summary).

Acoustic emission (AE) generated by the feeding of worker termite, *Reticulitermes speratus* (Kolbe), were detected from wooden construction members of a traditional Japanese warehouse. The AEs detected by piezoelectric sensors with a resonance frequency of 150 kHz were amplified about 66 dB, filtered through a high-pass filter of 100 kHz, and discriminated at a threshold voltages of 0.1 V, and the AE activity was estimated by a number of AEs counted for 10 min. Living termites in the galleries inside the beams were found near each detection point of AE by boring inspection. Neither AE nor evidence of swarming was detected after the attack points were treated with termiticide. AE monitoring as a nondestructive method for the detection of termite attack in actual wooden houses was feasible.

Detection of acoustic emission (AE) generated by termite attack in a wooden house, Y. FUJII, Y. YANASE, T. YOSHIMURA, Y. IMAMURA S. OKUMURA and M. KOZAKI : *The Int. Res. Group on Wood Preserv.,* Document No. IRG/WP99-20166 (1999).

Recently, considerable attention has been paid to methods for termite control, which involves few or no chemicals. To reduce the amount of termiticide needed, it is necessary to detect termite attack in the wood as early as possible. The feasibility of acoustic emission (AE) monitoring for the nondestructive detection of termite attack has been discussed previously. In this study, we propose some technical solutions for the application of AE monitoring to practical control operations. Using a needle-type waveguide combined with an AE sensor (PZT sensor), AEs generated and propagated within floors and walls could be detected effectively. A 0.04 mm-thick sample of the piezoelectric polymer PVDF, which was inserted between the construction members of wooden houses, could detect AEs propagated both in such members and at joint surfaces, although PVDF film is less sensitive than a PZT sensor. The feasibility of using a portable AE detector as the input device for a total security system against termite attack in a house is also discussed.

Drying and Anatomical characteristics of sugi wood attacked by bacteria during pond storage, Y. KOBAYASHI, I. IIDA, Y. IMAMURA and U. WATANABE : *J. Wood Sci.,* **44**(6), 432–437 (1998).

Seven species of bacteria were isolated and identified from ponded sugi (*Cryptomeria japonica* D. Don) logs, and six species showed potent wood-degrading activities. To evaluate the effects of these isolated bacteria on the drying and anatomical characteristics of wood, small fresh blocks of sugi were immersed in water suspensions containing bacteria for 1–7 months. The permeability and drying properties were evidently improved. Most of the encrusting substances adhering to the cell lumens and the pit chambers were removed, and the pit membranes were destroyed. These anatomical changes due to bacterial activity were assumed to improve the permeability of sugi wood.

Improvement of water movement of sugi wood by impregnation of bacteria using sap-flow method, Y. KOBAYASHI, I. IIDA, Y. IMAMURA and U. WATANABE : *J. Wood Sci.,* **44**(6), 482–485 (1998).

The sap flow method of wood impregnation was conducted to aid the movement of bacteria through the living tree, thereby accelerating their distribution through wood within a short time. When log-ponded water containing mixed species of bacteria were introduced in the living trees by butt-end dipping and then laid horizontally for 6 months, bacteria could be delivered by sap flow vertically through the sapwood tracheids up to the high portions from the butt-end of trees ; they could be detected in the ray parenchyma cells. The sap-flow method was assumed to deliver the bacteria to sapwood and heartwood at high levels of standing sugi (*Cryptomeria japonica* D. Don) trees. Degradation of the pit membranes was observed even at more than 3 m upward after the treatment in sapwood, as well as around the butt-end of the trees. The uptake of the aqueous dye solutions in sapwood of the treated logs was about eight times more than that of control specimens after 8 h.

Dominant genera of fungi isolated from the surfaces of sugi (*Cryptomeria japonica* D. Don) heartwood lumbers exposed at six test sites from northern to southern regions of Japanese islands, S. DOI, M. MORI, M. KIGUCHI, Y. IMAMURA, M. HASEGAWA, S. MORITA, S. NAKAMURA and Y. KADEGARU : *The Int. Res. Group on Wood Preserv.,* Document No. IRG/WP99-10304 (1999).

The surfaces of wood materials are disintegrated not only by sunlight and rainwater but also by microbes when exposed above ground condition. This paper deals with the investigation of fungi isolated from the surfaces of sugi heartwood lumbers (100 (W)×10 (T)×300 (L)) exposed at an angle of 45 degree without ground contact for 16 months at the six test sites from northern to southern regions of Japan. The parasites were collected from the surface using Sellotape. Isolation medium used was Potato-Dextrose-Agar plates including 100 ppm tetracycline-hydrochloride to prevent the contamination of

bacteria. Identifications were microscopically conducted using slide culture techniques. Dominant genera isolated were *Aureobasidium* and *Nigrospora* regardless of the test sites as well as climatic condition.

Removal of mercury and other metals by carbonized wood powder from aqueous solutions of their salts, L.L. PULIDO, T. HATA, Y. IMAMURA, S. ISHIHARA and T. KAJIMOTO: *J. Wood Sci.,* **44**(3), 237–243 (1998).

Sugi (*Cryptomeria japonica* D. Don) wood powder was carbonized at varying temperatures and used as a material to remove heavy metals from their aqueous solutions. Single solutions of mercuric chloride and mixed aqueous solutions containing lead nitrate, arsenic chloride, and cadmium chloride as well as mercuric chloride (1, 5, and 10 ppm) were prepared to determine the efficiency of removing heavy metals by these materials. Wood powder and carbonized wood at 200°C, 600°C, and 1,000°C removed mercury within the concentration range 1–10 ppm; mercury was perfectly removed even when mixed with other heavy metals. Wood powder carbonized at 1,000°C achieved the best removal of heavy metals among the wood-based materials and even commercial activated carbon in both single and mixed solutions.

Removal of mercury from aqueous solutions of mercuric chloride using wood powder carbonized at high temperature, L.P. NOVICIO, T. HATA, T. KAJIMOTO, Y. IMAMURA and S. ISHIHARA: *Wood Res.,* No. 85, 48–55 (1998).

Japanese cedar (*Cryptomeria japonica* D. Don) wood powder was carbonized at varying temperatures from 400°C to 2,400°C and used to remove mercury from 5 ppm mercuric chloride solutions. The removal efficiency of the carbonized wood materials changed depending on the carbonization temperature. The carbonization temperatures that provided wood powder with high removal capacity ranged from 600°C to 1,400°C. Low removal of mercury from the aqueous solutions was observed for carbonization temperatures below 400°C and above 1,600°C. The specific surface area of the carbonized wood materials was highly correlated with the capacity to remove mercury.

Performance of carbonized wood powder for purification of water contaminated with heavy metals, L. PULIDO-NOVICIO, T. HATA, T. KAJIMOTO, Y. IMAMURA and S. ISHIHARA: *Proceedings of the 4th Pacific Rim Bio-Based Composites Symposium,* 263–270 (1998).

Japanese cedar (*Cryptomeria japonica* D. Don) wood powder was carbonized at varying temperatures between 200 to 2400°C, and used as a material to remove heavy metals from their aqueous solutions. Mercury was removed even when ovendried wood powder was used, but carbonized wood powder could effectively remove mercury within the concentration range of 1–10 ppm, and mercury was preferentially removed even when mixed with heavy metals such as cadmium, lead and arsenic. Wood powder carbonized at 1,000°C achieved the best removal of heavy metals among the wood-based carbonized materials and even commercial activated carbon in both single and mixed solutions. The carbonization temperatures that provided wood powder with high removal capacity ranged from 600 to 1,400°C. Low removal of mercury from the aqueous solutions was observed for carbonization below 400°C and above 1,600°C. Wood powder carbonized at 1,000°C performed the best capacity of mercury removal from the aqueous solutions of different types of mercury compounds. Specific surface area was assumed to contribute to the capacity of carbonized wood materials to remove mercury.

Dynamic aspect of wood structure under thermal treatment, L. PULIDO-NOVICIO, T. HATA, T. KAJIMOTO and Y. IMAMURA: *Proceedings of the 2nd Int. Wood Sci. Seminar,* C21–29 (1998).

This study was conducted to observe the microscopic structure of Japanese cedar (*Cryptomeria japonica* D. Don) sapwood heated and carbonized at varying target temperatures and heating rates using environmental scanning electron microscope (ESEM) and conventional type scanning electron microscope (SEM). The weight loss and dimension shrinkage were also determined. Weight loss rapidly rose above 200°C and almost leveled off at 1,000°C, and the greatest weight loss occurred at the highest temperature for both heating rates. The degradation of cellulose was believed to be responsible for the abrupt increase in weight loss at 300°C, and weight loss increased continuously because of degradation of lignin components. Dimension shrinkage in the tangential, radial and longitudinal directions increased with carbonization temperature. Cracks were observed at higher heating rate due to excessive heating. ESEM was found to be a useful tool in directly and dynamically observing the structural features of wood heated at elevated temperatures. Change in the cellular structure was recognized starting from the temperature of 500°C. No prominent change was observed in the structure of wood such as cell arrangement at around this temperature and even when the temperature was raised up to above 1,000°C.

Separation of components of CCA-treated wood by flash pyrolysis, T. KAJIMOTO, T. HATA, Y. IMAMURA, M. TAKAGAKI and S. ISHIHARA: *4th Pacific Rim Bio-Based Composites Symposium Proceedings,* 320–324 (1998).

The disposal of waste CCA (Cr, Cu and As) treated wood is a growing problem due to emission or leaching of the harmful chemicals. To effectively separate the heavy metal compounds and wood-based components from CCA-treated wood, flash pyrolysis method was conducted. The surface portion of waste CCA-treated wood of western hemlock were shaved and ground for the CCA samples, and the inner portions were prepared for untreated samples. The samples were rapidly heated up to 590°C within one to four seconds under He-gas in the Curie-Point Pyrolyzer, and the emitted compounds were analyzed by GC-MS. The compounds which emitted first after heating were carbon oxide, carbon dioxide and acetic acid and were considered to be originated from cellulose and hemicellulose. Arsenic compounds bonded with methyl or methylene units of wood were detected from CCA treated wood when heated within four seconds, however, those were not recognized when heated within one second.

Furfural and benzene compounds were analyzed from both of untreated and CCA-treated woods, and levoglucosan and alcohol were also detected. These compounds were expected to be converted to bio-energy sources.

Changes of chemical structure of wood under carbonizing process, K. NISHIMIYA, T. HATA, Y. IMAMURA and S. ISHIHARA: *4th Pacific Rim Bio-Based Composites Symposium Proceedings,* 257–262 (1998).

The chemical structure of wood charcoal from sugi (*Cryptomeria japonica* D. Don) carbonized at various temperatures was analyzed by X-ray photoelectron spectroscopy (XPS), Fourier-transform infrared spectroscopy (FT-IR), and X-ray diffractometry. The carbon double bonds and aromatic rings were observed to be formed at a carbonization temperature of about 600°C. The ratio of aromatic rings rose in the temperature range of 800–1,000°C and over 1,800°C from the XPS spectra. These results showed that the condensation of aromatic rings proceeded as the carbonization process progressed. The drastic reduction of electrical resistivity of charcoals was observed in almost the same temperature range, suggesting that the condensation of aromatic rings had some relations to the decline in electrical resistivity. Wood charcoal carbonized at 1,800°C was graphitized partly based on the results of X-ray diffraction and XPS. The functional groups containing oxygen diminished with the increase of carbonization temperature. To develop XPS method for evaluation of surface chemical structure, solid wood of sugi was carbonized and irradiated by ultraviolet ray to investigate the effect of ultraviolet irradiation on the chemical bonding in wood charcoal by XPS. It indicated that the surface of wood and charcoal was oxidized after ultraviolet irradiation. XPS method clearly demonstrated that the extent of surface oxidation seemed to depend on the irradiation time.

Production of LVL by incorporating fire retardants in the glue—Analysis of the movement of chemical elements by X-ray photoelectron spectroscopy, T. HATA, Y. IMAMURA, S. ISHIHARA and H. KAJITA: *4th Pacific Rim Bio-Based Composites Symposium Proceedings,* 144–152 (1998).

Veneers of Japanese cedar (*Cryptomeria Japonica* D. Don) with different thickness and moisture content were bonded with phenol formaldehyde resin mixed with ammonium borate octahydrate or bromo-phenol resin at 200 g/m^2 of chemical retention. The distribution of the chemicals of fire retardants along the glue line of the two layered LVL specimens was evaluated with X-ray photoelectron spectroscopy (XPS). The distribution of boron from the glue lines was more extensive while pressing providing fire retardant properties to the LVL specimens. Wider distribution of the chemicals was detected in the specimens with larger amount of moisture than oven-dried ones. The specimens with optimum moisture established excellent performance in the dimensional stability and fire retardancy, which were influenced by the initial moisture content in the veneers and their thickness. There seemed to be some relations between those properties and the distribution of the glue and chemicals in wood cells.

Removal of mercury by carbonized wood materials from aqueous solutions of different types of mercury compounds of different types of mercury compounds, L.P. NOVICIO, T. HATA, T. KAJIMOTO, Y. IMAMURA and S. ISHIHARA: *Resource Processing Technology,* **46**(1), 3–8 (1999).

Japanese cedar (*Cryptomeria japonica* D. Don) wood powder carbonized at varying temperatures was used to remove mercury from aqueous solutions of different types of mercury compounds. Aqueous solutions of different types of mercury compounds were propared at 5 ppm to determine the amounts of mercury removed by these materials. In all cases, wood powder carbonized at 1,000°C performed best among the carbonized wood materials examines, even better than activated carbon. Mercury was removed even when ovendried wood powder and wood powder carbonized at 200°C were used. The ability of wood powder carbonized at 600°C to remove mercury was also promising.

Ultrastructual investigation for new application of wood charcoal under different thermal conversion techniques, T. HATA, L. PULIDO-NOVICIO and Y. IMAMURA: *Proc. of International Conference on Effective Utilization of Plantation timber,* 34–41 (1999).

Wood charcoal was carbonized or graphitized for the development of new functional wood composite products. A novel powder consolidation method was applied to wood charcoal. Graphitization of wood charcoal was observed using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The morphological change of cell structure and the microstructure during carbonization were continuously and directly examined by environmental scanning electron microscope. Japanese cedar (*Cryptomeria japonica,* D. Don), a fast growing species in Japan, was carbonized at heating treatment of 4–50°C/min from 20°C up to 1,300°C. The dynamic behavior of wood samples while subjected to thermal treatment was observed using an environmental scanning electron microscope(ESEM). Prominent change in cell structure was observed between 400°C and 500°C. On the other hand, the charcoal heated 600°C for 3 hrs showed a little shrinkage by increasing ambient temperature from room temperature till 1,300°C. New powder consolidation method was applied to the wood charcoal, to which pulse of electric current was directly applied. Bragg angle of the wood charcoal, analyzed by X-ray diffraction, became close to that of graphite at heat treatment of 1,770°C. The graphitization of wood charcoal was confirmed by TEM. The interlayer spacing in the wood charcoal sintered at 1,700°C for 5 min is almost the same as that of the wood charcoal carbonized at 2,300°C for 3 hrs.

Development of functional wood materials by combining different type of materials, Improvement of weatherability and fire retardancy, T. HATA: *Report on study result on wood composite materials,* 26–31 (1998) (in Japanese).

The trend and background of the study on improvement of weatherability and fire retardancy are reviewed.

Thermal constants of wood during the heating process measured with the laser flash method, T.

HARADA, T. HATA and S. ISHIHARA: *J. Wood Sci.*, **44**(6), 425–431 (1998).

The thermal diffusivity, specific heat, and thermal conductivity of 13 species of wood were measure by means of the laser flash method to investigate the thermal properties during the heating process. The temperature ranged from the room temperature to 270°C in air or under vacuum. The thermal diffusivity varied little during the heating process up to 240°C. The values in air were larger than those under vacuum. There was a linear relation between the specific heat and the ambient temperature, and the specific heat under vacuum was larger than that in air at high temperature. The thermal conductivity increased with density and the ambient temperature. To discuss the effects of the atmospheric conditions on the thermal constants of wood, a theoretical model of thermal conductivity was proposed and its validity examined, where wood was assumed to be a uniformly distributed material composed of cell walls and air.

Improving fire retardancy of fast growing wood by coating with fire retardant and surface densification, SUBYAKTO, T. KAJIMOTO, T. HATA, S. ISHIHARA, S. KAWAI and H. GETTO: *Fire and Materials,* **22**, 207–212 (1998).

Fire retardant fast-growing wood product was developed by coating with fire retardant and densifying the surface of wood. Trimethylol melamine formaldehyde resin mixed with phosphoric acid was coated on the wood surface, preheated and followed by hot pressing. Effects of the amount of coating, preheating temperature, and densifying ratio on the fire retardancy of sugi (*Cryptomeria japonica* D. Don) wood, and pressing temperature and pressing time on that of albizia (*Paraserianthes falcataria* Becker) wood were discussed. Bending strength, creep performance under fire and fire retardancy were evaluated. The results showed that the treatments improved the fire retardancy of woods without reduction in the bending strength.

Micro structural investigation of carbon fiber reinforcement in a silicone nitride matrix, T. HATA, P.M. BRONSVELD, J.TH.M.DE HOSSON, J.B. VEYRET and E. BULLOCK: *Proceedings of EUREM-II,* II-708–709 (1998).

The reason for the debonding within the fibers is given by TEM, HREM and SEM images and the role of the coating on the mechanical properties of the ceramic matrix composites is also discussed.

Enhancement of fire retardancy of wood composites by surface coating or densification, SUBYAKTO, B. SUBYANTO, T. KAJIMOTO, T. HATA, S. KAWAI and S. ISHIHARA: *4th Pacific Rim Bio-Based Composites Symposium Proceedings,* 153-160 (1998).

Wood and wood composites were surface coated with fire retardant or surface densified by hot pressing after coated. The mixture of trimethylolmelamine and phosphoric acid was used as fire retardant. The fire properties of the wood composites were evaluated using the creep test under fire and the standard fire test JIS A 1304. The two methods of surface coating (with or without densification) were evaluated. Enhancement of fire retardancy of the wood composites was discussed.

Effects of sintering temperature on structural changes of wood charcoal, T. YAMANE, S. ISHIHARA and T. HATA: *TANSO,* **186**, 2–6 (1999) (in Japanese with English summary).

Structural inspection of sintered charcoal were performed by X-ray diffraction analysis, SEM and TEM observation. The structure of sintered charcoal was changed by sintered temperature and had the graphite-like layered like structure and the turbostratic structure. The interlayer spacing of the charcoal sintered over 1,800°C became close to that of graphite and was 3.38–3.44 Å. It was found from the observation of cross section of sintered charcoal with SEM that the particles consisting of the sintered charcoal were compressed to be layer and that the lumens of the cell structure deformed like plastic elongation or destruction.

Clean-up environment with charcoal, Forestry Woods and Environment, T. HATA: Open Seminar of Kyoto University, 33–40 (1998) (in Japanese).

The fundamentals and application of wood charcoal for the purpose of clean-up environment are reviewed.

Micro structural investigation of wood carbon materials by electron microscopy, T. HATA, Y. IMAMURA, E. KOBAYASHI and H. KIKUCHI: *Proceedings of Japan Materials Science,* **48**, 355–356 (1999) (in Japanese).

The Spark Plasma Sintering method was applied to wood charcoal, whose volume electric resistance and thermal conductivity are similar to those of graphite. This paper explains the microstructure of onion-like graphitic particles in wood charcoal and graphite structure in sintered charcoal.

Acoustic properties of wood using for musical instruments, H. YANO: *Ultrasonic Technology,* **10**(8), 14–20 (1998) (in Japanese).

Acoustic properties of wood using for musical instruments and some chemical treatments to improve the acoustic properties were reviewed.

Towards the new millennium wood composites—The world strongest and weakest wood composites, H. YANO, P.J. COLLINS, Y. YAZAKI and S. DOI: *Proc. of 4th pacific Rim Bio-Based Composites symposium,* 226–235 (1998).

Three new type wood based materials were developed with a view to offering them as next century wood composites. When Douglas fir sawn plate was impregnated with a phenol-formaldehyde (PF) resin and compressed perpendicular to the grain at high temperature and pressure, the bending strength of the product was 535 MPa in the longitudinal direction, which is the highest reported bending strength of wood based materials. By hot-pressing mixtures of wood flour and bark tannin in a die at 190°C and at 100 MPa for 10 minutes, high strength plastic-like molded products were produced. The mechanical properties of these products are equivalent to those of engineering plastics. Tannin from radiata pine bark acted as adhesives without addition of formaldehyde. High strength plastic-like molded products were obtained

without any adhesives and chemical modifications, when radiata pine wood flours (<0.065 mm) were compressed in a die at 220°C and at 100 MPa for 10 minutes. When they were immersed in boiling water, they were readily disintegrated to become the weakest wood composite. Furthermore, the products were recyclable and biodegradable

Plastic-like molding products made from wood flour and tannin, H. YANO, P.J. COLLINS, Y. YAZAKI and S. DOI: *Proc. of 28th symposium on chemical treatment of wood, Kumamoto,* 27–34 (1998) (in Japanese).

Molding products having high strength comparable to engineering plastics were prepared by hot-pressing mixtures of wood flour and radiata pine bark tannin in a die at 190°C and at 100 MPa for 10 minutes. Tannin from radiata pine bark acted as adhesives without addition of formaldehyde. High strength plastic-like moulded products were obtained without any adhesives and chemical modifications, when radiata pine wood flours (<0.065 mm) were compressed in a die at 220°C and at 100 MPa for 10 minutes. When they were immersed in boiling water, they were readily disintegrated to become the weakest wood composite. Furthermore, the products were recyclable and biodegradable.

Glued-in hardwood dowels as an alternative timber end-jointing device—An introduction of the recent research topic in the field of Japanese timber engineering—, K. KOMATSU: *Otto-Graf-Journal,* **9**, p. 135–152, (1998).

As a recent research topic in the field of Japanese timber engineering, glued-in hardwood dowels joint was introduced. Tensile strength of glued-in dowel joints was found to be controlled by two parameters, one of which is the glue line shear strength f_{vs} and another is shear stiffness Γ which was defined as a proportional coefficient between glue line shear stress τ and relative displacement between dowel and wood member. From pull-out test and push-out test, glue line shear strength f_{vs} was estimated as 7.6 to 9.4 MPa for polyurethane adhesive and 10.9 to 12.9 MPa for epoxy adhesive in the case of Japanese maple dowel and Japanese cedar main member. Shear stiffness Γ evaluated two different test methods was varied from 9.3 to 43.6 N/mm^3 for polyurethane adhesive and 45.2 to 73 N/mm^3 for epoxy resin adhesive. Flexural properties of glulam beams, which were end-jointed by glued-in hardwood dowels, were analyzed theoretically and also examined by experiment using glued-in dowel jointed glulam beams of 100×200 mm cross section and 2,700 mm total span length made of Japanese cedar. Good agreements were obtained between theoretical prediction and experimental observation.

Development of lagscrewbolt as a connector for glulam moment-resisting loints, K. KOMATSU, Y. HARA, Y. NANAMI and T. IKKI: Proceedings of the Pacific Timber Engineering Conference, **2**, 349–354, Rotorua, NZ. (1999).

A new type of mechanical fastener called as "Lagscrewbolt" was developed by the authors. This connector is made of steel whose outer part has the same appearance and function as those of threaded part of lagscrew and in the inside of top shank, the same shape and function as those of threaded part of nut for bolt are installed, so that it was named as "Lagscrewbolt". For this connector, we only expect pull-out or push-out resistance perpendicular to the grain direction at this moment. A series of pull-out experiment was done on the specimens made of Douglas-fir glulam members in which a Lagscrewbolt was embedded perpendicular to the grain until various depth (from 2*d* to 10*d*, *d* is the outer diameter of the Lagscrewbolt). Pull-out strength and slip modulus were fitted by least squares method so as to be expressed in terms of quantity per unit embedment length, from which design embedment length for any particular beam-column joints of glulam frame structures could be estimated on demand. Then, full-scale experiments were conducted using L-shape joint specimens to evaluate the performance of glulam moment-resisting joints which were composed of Lagscrewbolts and usual high-tension steel bolts. Strength performance of L-shaped moment-resisting joints were not so good because of unexpected shear failure at bolted joint occurred prior to full performance of Lagscrewbolt was appeared. Further modifications for this joint method are still being discussed.

Timber joints No. 1–No. 5, K. KOMATSU: *"Konsaisu Mokuzai Hyakka",* ed. by Y. Iijima et al., p. 214–223, Akita Mokuzai Suishin Kikou (1998) (in Japanese).

Basic concept on timber joints were briefly explained for readers who are studying basis of timber engineering.

Timber bridges, K. KOMATSU: "The Encyclopedia of Wood Industry", ed. by T. Hisada et al., p. 218–219, Wood Technological Association of Japan, (1999) (in Japanese).

Definitions and brief introduction to new timber bridges were involved in this encyclopedia.

Research and developments on joints for timber constructions in recent Japan, K. KOMATSU: Proceedings of International Conference on Effective Utilization of Plantation Timber (ICEUPT'99), 370–377, May, Chitou, ROC (1999).

Research and development for glulam moment-resisting joint might be one of the most difficult but worth challenging subject in the field of timber engineering for the author. In this overview report, previous researches and developments on the glulam moment- resisting joints done mainly by the author were briefly reviewed from the first attempt to the modified ones. Some applications of moment-resisting joints as well as newly developed timber jointing technique to actual timber structures were also introduced briefly.

Experimental study on structural behaviour of laminated heavy timber bridge, K. KOMATSU, M. INOUE and T. MAYUMI: Proceedings of the 7th East Asia Pacific Conference on Structural Engineering & Construction (EASEC-7), Kochi, Japan (1999).

'Kanma-bashi' bridge was constructed at Kuju-machi in Kyushu Island in 1998. Large cross sectional glued laminated timber (glulam) composed of Sugi laminae was used for the structural members of this bridge. In the

middle part of this bridge, a π shaped gluam girder was used. Destructive loading test was carried out by the authors on a 1/3 scale model specimen for the π shaped girder. A simplified calculation method to derive the ultimate strength of this specimen was proposed, and the test results showed a good agreement with the value calculated by the proposed method.

Developmant of compressed wood fasteners for timber construction II. Lateral resistance of drift-pin joints with compressed LVL plates in loading parallel to the grain, K. NAKATA, H. SUGIMOTO, M. INOUE and S. KAWAI : *J. Jpn. Wood Res. Soc.*, **44**(4), 247–254 (1998) (in Japanese).

Rotary-cut veneers of Sugi (*Cryptomeria Japonica* D. Don) were impregnated with low-molecular weight phenolic resin and pressed into compressed laminated veneer lumber (LVL) of parallel laminates (P-type) or crossbanded laminates (C-type) by hot pressing. The tension-type lateral strengths of drift-pin joints with compressed LVL plates were tested in parallel to the grain loadings. The lateral resistance, the slip modulus, and the maximum deformations of these joints were compared with drift-pin joints with the steel plates. The results were as follows : 1) The P-type plates were split into two members instantaneously at the maximum loads, showing a brittle behaviors. However, the C-type plates uxhibited very ductile behaviors, where the pins were embedded into the compressed LVLs continuously. Ultimately, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) glulams were split into twos. 2) The lateral resistances of the joints with the C-type plates were greater than those with the P-type plates, and the same as those with the steel plates. 3) The slip modules of each joint with the LVL plate was less than that with the steel plate, because the slip deformation of the LVL plate to that of the glulam was added. 4) The maximum deformation of the joint with the C-type plate was much greater than that with the steel plate. In the case of setting the thickness of the plate and glulam properly, in addition to the maximum deformation, the lateral resistance and the slip modules increased.

Manufacture and properties of particleboard using herbaceous plants from a dry river-bed, M. ZHANG, S. KAWAI, M. NAKAJI and K. NAKAI : *J. Jpn. Wood Res. Soc.*, **44**(4), 255–261 (1998) (in Japanese).

The variety and quantities of various herbaceous plants available in the dry bed of the Yodogawa River were investigated. Chigaya (*Imperata cylindrica* Linn.) and seitakaawadachiso (*Solidago altissima* Linn.) were chosen as the raw materials for the manufacturing of particleboards. The influences of adhesive types, grass species, and particle configurations on board properties are discussed. The effectivenesses of mixtures of urea formaldehyde (UF) resin and emulsion-type isocyanate (E-MDI) resion for upgrading board propertias were examined.

The internal bond (IB) strengths of boards bonded with only UF or urea melamine formaldehyde (UMF) resin were very small, due to the retardation of resin hardening. Mixtures of UF and E-MDI resins were used to improve the IB and bending strengths of the boards. The resin contents used in these UF and E-MDI mixtures were 10%. The UF and UMF mixing ratios were 10/0, 9/1, 8/2, and 6/4. The mechanical properties and dimensional stabilities of the boards were improved greatey by replacing 20–40% of the UF using E-MDI. In addition, the influences of particle sizes and configurations on the dimensional stabilities were observed. The water resistance of chigaya particleboards bonded with only polymeric-type isocyanate (P-MDI) resin was small, but the bending strengths of the boards were comparable to those of commercial wood-based particleboards.

Manufacture of bamboo-cement composites III. Effects of sodium carbonates on cement curing by steam injection pressing. L. MA, Y. KUROKI, W. NAGADOMI, S. KAWAI and H. SASAKI : *J. Jpn. Wood Res. Soc.*, **44**(4), 262–272 (1998) (in Japanese).

This study dealt with the effects of the additions of sodium carbonates ($NaHCO_3$, Na_2CO_3) or their combinations with $MgCl_2$ on the degree of curing and on the properties of cement-bonded bamboo composites (CBC) manufactured by steam injection pressing. Their hydration degrees were examined by X-ray diffraction (XRD), scanning electron microscope (SEM), and thermogravimetric differential thermal analysis (TG-DTA). The results are as follows : 1) The initial setting of cement is accelerated by the addition of sodium carbonates. Although there was not much difference between the effects of the addition of $NaHCO_3$ and Na_2CO_3, there was some improvement in the hydration rate and the board properties with increases in additive content, however, these are not significant enough, 2) Cement hydration was not improved during water soaking because the Ca $(OH)_2$ and CO_2 generated from the cement clinker and the sodium carbonates, respectively may have reacted to form $CaCO_3$ which covered the cement clinker, 3) The hydration of cement under water-soaked condition was also accelarated by the addition of sodium carbonates in combination with $MgCl_2$, and the modulus of rupture (*MOR*) of CBC exceeded 100 kgf/cm^2 with the addition of 10% carbonates of sodium and 5% $MgCl_2$, 4) CBC manufactured at 2.6 cement/bamboo ratio have better mechanical properties than those at a 2.2 ratio, and 5) There were high correlations between the mechanical properties of CBC and the XRD intensity of the cement clinker and C_3S, the weight losses at 200°C and at 900°C under TG-DTA, and the estimated yield of $Ca(OH)_2$. From these relationships, the mechanical properties of bamboo CBC using carbonates as additives might be predicted.

Manufacture of bamboo-cement composites IV. Effects of sodium silicate on cement curing by steam injecting pressing, L. MA, Y. KUROKI, W. NAGADOMI, O.R. PULIDO, S. KAWAI and H. SASAKI : *J. Jpn. Wood Res. Soc.*, **44**(4), 273–281 (1998) (in Japanese).

This study dealt with the effects of water/cement ratio, cement/bamboo ratio, and the additions of sodium silicate (Na_2SiO_3) or their combinations with $MgCl_2$ on the degree of cement hydration and on the properties of cement-bonded bamboo composites (CBC) manufactured with steam injection pressing. The hydration degrees of the composites were examined by X-ray diffraction (XRD),

scanning electron microscope (SEM), and thermogravimetric differential thermal analysis (TG-DTA). The results are as follows: 1) Under water-soaking condition, the properties of CBC were hardly affected by the weight ratio of water/cement in the range of 0.4 to 0.7. 2) The properties of CBC were varied by changing the weight ratio of cement/bamboo. Where flexural properties were concerned, the optimum cement/bamboo weight ratio was estimated to be 2.6 at the water/cement weight of 0.6. 3) The cement hydration was accelerated and the CBC properties were improved by the addition of Na_2SiO_3 of less than 15%. The addition of Na_2SiO_3 in combination with $MgCl_2$ was more effective than that of Na_2SiO_3 alone on accelarating the cement hydration under water-soaking condition and the mechanical properties of CBC were improved. 4) The mechanical properties of CBC made with these additives were much higher than those of CBC made with additives of sodium carbonates. The optimum additive content for Na_2SiO_3 alone was found to be 15%, or a combination of 10% Na_2SiO_3 and 5% $MgCl_2$. 5) The mechanical properties of CBC depends directly on the degree of cement hydration.

Manufacutre and properties of high-performance oriented strand board composite using thin strands, M. ZHANG, E. WONG, S. KAWAI and J. KWON: *J. Wood Science,* **44**(3), 191–197 (1998).

Three-layered composite oriented strand boards were manufactured using very thin hinoki (Japanese cypress, *Chamaecyparis obtusa* Endl.) strands oriented in the faces and mixtures of sugi (Japanese cedar, *Cryptomeria japonica* D. Don.) and hinoki particles in the core. The boards were composed of two density levels, with 1 : 8 : 1, 0.5 : 9 : 0.5, and 0 : 10 : 0 face : core : face ratios. Polymeric and emulsion type isocyanate resins were used. The resin contents for the strands in the face and particles in the core were 10% and 5%, respectively. The steam-injection press was applied at 0.62 MPa (160°C), and the steam-injection time was 2 min. The mechanical and physical properties of the boards ware evaluated based on the Japanese Industrial Standard. The parallel moduli of rupture and elasticity along the strand orientation direction and the wood screw retaining force increased with increasing face/core ratios. Incorporation of 10–20% of thin strands in the face of the boards improved the parallel moduli of rupture and elasticity by 47–124% and 30–65%, respectively. In addition, the thickness swelling after water-soaking at 20°C for 24 hr, and the parallellinear expansion after boiling for 2h and water-soaking at 20°C for 1 hr, of the three-layered composite boards were below 8% and 0.15%, respectively, despite a short steam-injection press time. The thickness swelling of the boards decreased with increasing face/core ratios. In contrast, the presence of face strands seems to have a minimal effect on the moduli of rupture and elesticity along the perpendicular direction of the three-layered composite boards. A similar trend was observed for the internal bond strength, hardness, and linear expansion along the perpendicular direction.

Durability of isocyanate resin adhesive for wood I. Thermal properties of isocyanate resin cured with water, K. UMEMURA, A. TAKAHASHI and S. KAWAI: *J. Wood Science,* **44**(3), 204–210 (1998).

The thermal properties of isocyanate (IC) resin cured with water were studied using dynamic mechanical analysis (DMA) and Fourier transform infrared spectroscopy. The thermal properties of cured phenol formaldehyde (PF) resin were also studied for comparison purposes. The DMA specimens were prepared using a unique technique. The relation between the mechanical and chemical changes of the resin during DMA was clarified. The cured PF resin had better thermal stability than the IC resin cured with water. The improvement of thermal stability in cured IC resin by heat treatment was considered to be less effective. The effect of the heating rate on the mechanical properties was also investigated. The apparent activation energy in the thermal degradation of cured IC resin was calculated based on the rusults obtained.

Upgrading of urea formaldehyde-bonded reed and wheat straw particleboards using silane coupling agents, G. HAN, C. ZHANG, D. ZHANG, K. UMEMURA and S. KAWAI: *J. Wood Science,* **44**(4), 282–286 (1998).

Reed and wheat straw particleboards bonded with urea formaldehyde (UF) resin were manufactured from two different material configurations (i.e., fine and coarse particles). The board densities were in the range of 0.55–0.90 g/cm^3. The effects of particle size and board density on the board properties were examined. The properties of particleboard produced from fine particles were better than those made from coarse particles. An increase in board density resulted in a corresponding improvement in the wheat straw particleboards were relatively lower than those of commercial particleboards. Three silane coupling agents were used to improve the bondability between the reed and wheat particles and UF resin. Results of this study indicate that all the board properties were improved by the addition of silane coupling agent. The degree of improvement achieved from each coupling agent was different; epoxide silane was found to be more effective for reed straw particleboard, and amino silane was better for wheat straw particleboard.

Effects of mat moisture content and press closing speed on the formation of density profile and properties of particleboard, E. WONG, M. ZHANG, Q. WANG and S. KAWAI: *J. Wood Science,* **44**(4), 287–295 (1998).

Isocyanate resin-bonded 0.5 and 0.7 g/cm^3 lauan (*Shorea* sp.) particleboards were produced from mats with uniform and distributed moisture content (MC) distributions, using three hot press closing speeds. The effects of there processing variables on the formation of density profile in particleboard and board properties were analyzed statistically. A definition of the density profile was introduced, and the correlations among the various defining factors were established. The results are summarized as follows. (1) The peak density (PD) of particleboard could be increased, with a slight reduction in the core density (CD), using mats with different MC distribution. (2) In a conventional density profile, CD and PD are highly dependent on the board mean density

(MD); and the gradient factor (GF), peak distance from the faces (Pdi), and peak base (Pb) are significantly correlated to each other, at the 99% significance level. (3) Greater press closing speed reduces Pdi and Pb, with an increase in GF. (4) Greater press closing speed could increase the PD in board of low MD, with minimal effect on CD. (5) The modulus of elasticity (MOE) of particleboards from mats with high MC near the faces were consistently higher than those from mats with uniform MC, irrespective of the press closing speed, whereas their modulus of rupture (MOR) became indifferent a higher MD under slow and fast closing speeds. (6) Sanding does not improve the MOR and MOE of particleboard significantly.

Manufature and properties of ultra-low-density fiberboard, T. KAWASAKI, M. ZHANG and S. KAWAI : *J. Wood Science,* **44**(5), 354–360 (1998).

Low-density fiberboards with densities ranging from 0.05 to 0.50 g/cm^3 were manufactured with steam injection pressing. Bond-type and foam-type isocyanate compound resin adhesives were used separately at 10% and 30% resin content levels. Two types of different-size fibers from softwood were used. Mechanical, dimensional, thermal, and sound insulation properties of the fiberboards were tested. The results are as follows: (1) Bond-type isocyanate adhesive showed higher mechanical and dimensional properties of low-density fiberboards than the foam-type adhesive. (2) Fiberboards produced from small fibers have better mechanical and dimensional properties than those made from large fibers. (3) Thermal conductivity of fiberboards depends more on the board density than on the type of resin or fiber dimension. At a board density lower than 0.2 g/cm^3, the thermal conductivity is almost equivalent to those of thermal insulation materials such as polystyrene foam and rock wool. (4) Generally, the sound absorpsion coefficient of low-density fiberboards tends to increase at higher sound frequency. As the board thickness increases, low-frequency sounds are more readily absorbed by boards.

Effect of various isocyanate resin adhesives on particleboard properties, K. UMEMURA, K. KAWAI and H. SASAKI: *J. Wood Science,* **44**(6), 417–424 (1998).

The effects of chemical structure and free isocyanate content (NCO) of isocyanate resin adhesives on the properties of particleboards were investigated. Fourteen kinds of resins with various isocyanates and polyols were used as adhesives. Particleboards with densities of 0.3–0.6 g/cm^3 were manufactured. The moduli of rupture and elasticity, internal bond strength, thickness swelling and water absorption of the boards were measured based on JIS (Japanese Industrial Standard) A 5908.

The mechanical properties of the boards were greatly affected by the isocyanate structure of the adhesives. The dimensional stability of the boards was also affected by the NCO content and polyol structure. The effects of the adhesive characteristics became more evident at higher board specific gravity. The board bonded with the adhesive containing toluene diisocyanate (TDI) showed remarkably inferior performances. In the case of 8% resin content, NCO content of 10% or above in the adhesive was required to obtain satisfactory board properties. The effects of resin content and polyol were also investigated on the basis of NCO content based on oven dry particle weight. The board properties improved with increasing NCO content. At equal NCO content, particleboard bonded with neat polymeric diphenyl methane diisocyanate (polymeric MDI) was found to be inferior to polyol-introduced polymeric MDI.

Manufacture of bamboo-cenent composites V. Effects of sodium silicate on bamboo cement composite by hot pressing, L. MA, O.R. PULIDO, H. YAMAUCHI, S. KAWAI and H. SASAKI: *J. Jpn. Wood Res. Soc.,* **44**(6), 425–432 (1998) (in Japanese).

Mousou bamboo (*Phyllostachys heterocycla* Mitf. var. *pubescens* Ohwi) semi-flakes were used as raw materials for the manufacture of cement-bonded bamboo composites (CBC) by hot pressing to clarify the effects of pressing temperature, pressing time, and the additive content of sodium silicate (Na_2SiO_3) on the degree of cement hydration and on the board properties. The hydration degrees of the composites were examined by X-ray diffraction (XRD) analysis, scanning electron microscope (SEM) observation, and thermogravimetric differential thermal analysis (TG-DTA). The results were as follows: 1) The initial setting of cement was accelerated by hot pressing with Na_2SiO_3 and rapid curing of CBC was achieved. The cement hydration was accelerated, and the CBC properties were improved by the addition of Na_2SiO_3. The optimum additives content for Na_2SiO_3 was found to be 15% to 20% based on the cement weight. 2) Hot press temperature affected the hydration of cement, and the values of the mechanical properties of CBC pressed at high temperature were greater than those pressed at a low temperature. HRD and TG-DTA analyses showed that the initial setting of cement was slow at lower temperature. Therefore the springback of CBC after pressing was not controlled. Although the hydration of cement was improved by curing under water-soaked condition, the mechanical properties of CBC were not enhanced. In the case of CBC pressed at a high temperature ($>100^\circ$C), the springback of CBC was suppressed since the initial setting of the cement was accelerated but curing under water-soaked condition barely improved the hydration of the cement. SEM analysis also showed better structure of CBC pressed at higher temperatures. 3) Hot pressing time affected the hydration of the cement. In the range from 3 to 21 min, long hot pressing times resulted in improvements of CBC properties.

Improving fire retardancy of fast growing wood by coating with fire retardant and surface densification, SUBYAKTO, T. KAJIMOTO, T. HATA, S. ISHIHARA, S. KAWAI and H. GETTO: *Fire and Materials,* **22**: 207–212 (1998).

Fire retardant fast-growing wood product was developed by coating with fire retardant and densifying the surface of wood. Trimethylol melamineformaldehyde resin mixed with phosphoric acid was coated on the wood surface, preheated and followed by hot pressing. Effects of the amount of coating, preheating temperature, and densifying ratio on the fire retardancy of sugi (*Cryptomeria japonica* D. Don) wood, and pressing temperature and pressing time

on that of albizia (*Paraserianthes falcataria* Becker) wood were discussed. Bending strength, creep performance under fire and fire retardancy were evaluated. The results showed that the treatments improved the fire retardancy of woods without reduction in the bending strength.

Manufacture of bamboo-cement composites VI. Effects of silica fume addition and heat treatment on properties of hot-pressed boards, L. MA, S. KAWAI and H. SASAKI: *J. Jpn. Wood Res. Soc.*, **45**(1), 25–33 (1999) (in Japanese).

In the previous paper, it was proved that cement-bonded bamboo composites (CBC) can be manufactured in a short press time with with the addition of Na_2SiO_3 and hot-pressing. The present paper concerns the improvement of the process by additional heat treatments combined with the addition of silica fume to further shorten the CBC curing time. The effects of the addition of silica fume, heat-treatment temperature and time, effect of hot-press time on the degree of cement hydration and the properties of CBC, are discussed. The hydration degrees of the composites were examined by X-ray diffraction (XRD), scanning electron microscope (SEM), and thermo-gravimetric differential thermal analysis (TG-DTA). The results were as follows: 1) CBC properties were improved with additional heat treatment, especially with the combination of heat treatment and the addition of silica fume. 2) In the case of using additional heat treatment the optimum amount of addition of silica fume was 5%. The cured structures were more compact at a 5% addition of silica fume and the interface between bamboo and cured cement might have been improved. 3) CBC properties were improved markedly at a heat treatment temperature of 100°C than those at 60°C and 80°C. 4) The longer hot-press time resulted in better mechanical properties of CBC. The final properties of CBC were related to their initial strength and hydration degree (strength and hydration degree, respectively, immediately after hot-pressing). The optimum condition of CBC manufacture were: the addition of 15% Na_2SiO_3 and 5% silica fume, 11-min hot-pressing at 110°C, 24 hr heat treatment at 100°C.

Manufacture of cylindrical LVL by spiral-winding method II. Fast-setting adhesives for cylindrical LVL manufacture, H. YAMAUCHI, I. MIURA, T. HATA, TAMURA, S. KAWAI and H. SASAKI: *J. Jpn. Wood Res. Soc.*, **45**(2), 149–156 (1999) (in Japanese).

To increase the yield and improve efficiency in the manufacture of cylindrical LVL using the spiral winding process, various methods are being considered. The simplest and most effective is the use of fast-setting adhesives (FSA) which can be cured at low temperatures and short press times. These can be mixed with additive resins (AR) which have special properties and/or smaller costs. Two types of adhesive mixtures wese studied, 1) Urea formaldehyde resin in combination with isocyanate resin (UF-mixture), and 2) Fast setting resorcinol meta-aminophenol in combination with ordinary resorcinol resin (RF-mixture). Sawed veneers of katsura (*Cercidiphyllum japonicums* S. et Z.) were used as test pieces. The physical properties, adhesive strength, and durability of the adhesives and adhesive mixtures were studied. The adhesive strength were determined through shear tests in tension. 1) After the first 20 minutes of pressing for either of the two types of adhesive mixtures, the development in adhesive strength was slow, when the FSA content was less than 50%. For the UF-mixture, the strength value leveled off after 100 minutes. On the other hand, the strength of the RF-mixture did not level off even after 24 hours. 2) In the case of the UF-mixture, the addition of isocyanate resin hardly improved the durability of the bond. 3) The durability of RF-mixture was improved by the addition of ordinary resorcinol resin.Espicially, the mixing ratio of 2/1 (AR/FSA) resulted in good performance of glued veneers in the durability tests, enough for structural uses. 4) Press time (1–5 min) and pressure (0.3–1.2 MPa) hardly influenced the adhesive strength and wood failure of the RF-mixture at 2/1 mixing ratio.

New methods of production and treatment of bamboo-cement composites, L. MA, O.R. PULIDO, H. SASAKI, Y. KUROKI, W. NAGADOMI and S. KAWAI: Proc. 6th Inorganic Bonded Wood & Fiber Composite Materials Conf., p. 315–322, 27–30 Sep., Idho, U.S.A. (1998).

The hydration temperature and hardness of mixtures of bamboo (*Phyllostachys heterocycla* Mitf. var. *pubescens* Ohwi) powders and cement were examined. The inhibitory index, I and compatibility factor, C_A were determined. Extraction of bamboo powders by cold water, hot-water and 1% NaOH solution can moderate the inhibitory effects in the hydration reaction of bamboo-cement mixture.

The hydration rates of cement in cement-bamboo composite boards produced by cold pressing, steam injection pressing or hot pressing method were investigated by TG-DTA and X-ray diffractometry, XRD, scanning electron microscope, SEM. Board properties were tested according to the Japan Industrial Standards JIS A5908. The effects of some additives on the hydration of bamboo cement mixture and the hardness of the cured paste were studied. The additives were, sodium hydrogen carbonate, sodium silicate, calcium chloride, and magnesium chloride. The rise in hydration temparature with respect to time varied depending on the additive used. Large amounts of additives resulted to higher values of hydration temperature peaks, T_{max}. Based on the hydration temperature, magnesium chloride and calcium chloride improved the compatibility of bamboo powder and cement. High correlations between Tmax or the compatibility factor, C_A and dhe modulus of rupture, MOR of cement-bamboo composites were obserfed.

The yields of $Ca(OH)_2$ resulting from the hydration of cement clinkers were estimated from the XRD and TG-DTA analyses. There were high correlations between the mechanical properties of cement-bonded composite, CBC and the XRD intensity of the cement clinker and C_3S, the weightlosses at 200°C and 900°C undur TG-DTA, and the estimated yield of $Ca(OH)_2$. From these relationships, the mechanical properties of bamboo CBC using carbonates as additives might be predicted.

Where the flexural properties were concerned, the optimum bamboo/cement ratio was estimated to be 2.6 at the water cement ratio of 0.6 when the steam injection pressing method was employed. Hot pressing time

affected the hydration of cement. In the range of 3 min to 21 min, long hot pressing times resulted in the improvements of CBC properties. CBC properties were markedly improved at 100°C heat treatment temperature than at 60°C or 80°C. The final properties of CBC were related with their initial strength and hydration degree (strength and hydration degree, respectively, immediately after hot pressing). The optimum conditions of manufacture of CBC by hot pressing were: addition of 15% Na_2SiO_3 based on cement weight, substitution of 5% cement with silica fume, 11 min hot pressing at 110°C, 24 hr heat treatment at 100°C.

Development of conversion technologies of low-grade wood resources into higher-grade laminated veneer products, H. SASAKI, H. YAMAUCHI and S. KAWAI: Forstry Towards the 21st Century (Proc. of the Workshop for the 40th Anniversary of Chinese Academy of Forstry), p. 525–529, 27, Oct., Beijing, China (1998).

This paper is the summary of the authors' researches that have been made during these twenty years on the development of conversion technologies of low-grade wood resources into higher-grade laminated veneer products. Those are: 1) Development of peripheral drizen veneer lathes with powered toothed wheels and with powered backup rolls for peeling small diameter logs such as thinnings from plantation forest and their commercialization. 2) Development of continuous presses with radio-frequency heating and steam-injection heating systems for manufacturing endless LVL. 3) Conversion of fast-growing plantation trees of Japanese softwood and tropical hardwood species into Laminated Veneer Lumbers (LVL) and its industrial application. 4) Development of manufacturing process and machine for cylindrical LVL columns with a helical winding method. 5) Application of the cylindrical LVL columns to the building constructions.

Effests of the formulation of isocyanate resins on the properties of particleboard, S. KAWAI, K. UMEMURA, H. SASAKI and K. MATSUO: Proc. 4th Pacific Rim Bio Based Composites Symposium, p. 65–70, 2–5 November, Bogor, Indonesia (1998).

The effects of isocyanate resin formulation, free isocyanate (NCO) group content and board resin content on the properties of particleboards were investigated. Particleboards of 0.4 and 0.6 g/cm^3 densities were manufactured with various types of isocyanate resins formulated with different isocyanates and polyols. The moduli of rupture and elasticity, internal bond strength, thickness swelling and water absorption of the boards were measured based on JIS A 5908.

The mechanical properties and dimensional stability of the boards were greatly affected by free-NCO group content and resin content of isocyanate resin adhesives. The board properities improved with increasing free-NCO content. At equal resin content, particleboards bonded with diphenyl methane diisocyanate (MDI) resin alone and unreacted mixtures of MDI and polyols were found to be inferior to the polyol-introduced compound MDI resin. The isocyanate structure of the adhesives affected the board properties as well. The effects of the adhesive characteristics became more evident at higher board density. In the case of 8% board resin content, isocyanate adhesive with a free-NCO group content of 10% or above was remained to obtain satisfactory board properties.

Thermal properties of isocyanate resin adhesives for wood, K. UMEMURA, A. TAKAHASHI and S. KAWAI: Proc. 40th Pacific Rim Bio Based Composites Symposium, p. 71–79, 2–5, November, Bogor, Indonesia (1998).

The utilization of isocyanate (IC) resin adhesives has been on the increase since formaldehyde emission from wood products utilizing formaldehyde based resin adhesives has become a public concern. The NCO group-water reaction is considered to be one of the most important reactions in bonding wood composite materials with IC resin adhesives.

In this study, the thermal properties of aqueous emulsion type IC resin cured with water were determined using dynamic mechanical analysis (DMA) and fourier transform infrared spectroscopy (FT-IR). The DMA specimens were prepared using special technique to prevent the formation of cracks in the cured brittle IC resin. The specimens of IC resion were cured at 40°C for 24 hr in an oven.

When the cured IC resin was heated to 200–220°C at 6°C/min, a sudden dip and temporary recovery of the storage modulus (E') was observed. Based on the change of IR spectra, the behavior of E' at around 220°C could be attributed to the segmental motion and rearrangement. Thereafter, E' recorded a rapid decrease with increasing temperature, followed by a temporary increase from 300 to 325°C. To investigate the effect of heat treatment, the cured IC resins were heated at 160, 200 and 300°C for 10 min, respectively. However, these treatments were considered not very effective. The dependence of the mechanical properties of cured IC resin on the rate of heating was investigated. When the heating temperature was above 300°C, significant degradation reactions seemed to have taken place. Based on the results obtained, the apparent activation energy of the thermal degradation at above 300°C was calculated. The effect of the addition of cellulose powder on the mechanical properties of cured IC resin was also investigated. The cellulose powder was believed to interact strongly with IC resin.

Density profile -its formation and effects on the properties of particleboard-, E. WONG, M. ZHANG, Q. WANG and S. KAWAI: Proc 4th Pacific Rim Bio Based Compositec Symposium, p. 173–180, 2–5 November, Bogor, Indonesia (1998,).

Particleboards with flat density profile (homo-profile) and conventional U-shaped profile along the thickness, were manufactured using lauan (*Shorea* spp.) bonded with an isocyanate resin. In both the homo-profile and conventional particleboards, the modulus of rupture (MOR), Young's modulus (MOE), internal bond (IB) strength, and wood screw holding power (WSHP), are highly correlated to the board mean density in a curvelinear trend. At equal mean density (MD) level, the conventional board recorded higher MOR and MOE, but lower IB, compared to the homo-profile board, due th the presence of U-shaped density profile. The peak density

(PD) could be increased most effectively by varying the mat moisture content distribution, where peak distance (Pdi) from the surfaces was reduced by accelerated press closing speed. The effects of processing variables on the board properties were analyzed statistically. A density profile definition was introduced, and the correlations among the various density profile defining factors were established. The bending properties of particleboards with different density profiles were also analyzed by calculating their modulus of elasticity (MOE) using two dimensional finite element method (FEM). Increment in PD results in a proportional increase in MOE, but the reverse is true for Pdi. In idealized density profile models, when PD and core density remain unchanged, the maximum peak area does not necessarily result in the highest MOE. Multiple regression analysis reveals that the MOE of particleboard depends basically on the board MD, PD and Pdi.

Low-density fiberboard and veneer Overlaid fiberboard, T. KAWASAKI, M. ZHANG and S. KAWAI: Proc. 4th Pacific Rim Bio Based Composites Symposium, p. 195–202, 2–5 November, Bogor, Indonesia (1998).

Low-density fiberboards with the densities of 0.05–0.50 g/cm^3 were manufactured from softwood fiber. Low-density sandwich panels with the core material of softwood fiber overlaid with veneers on top and bottom faces were produced at the densities of 0.3–0.5 g/cm^3. These boards were bonded with an isocyanate compound resin adhesive and produced using steam injection press. The mechanical, dimensional, and thermal insulation properties of these boards were investigated.

The mechanical strength of homogeneous fiberboards were remarkably improved by overlaying with veneers. These low-density fiberboards and sandwich panels had very good dimensional stabilities, with negligible spring-back after accelerated weathering conditions. The thermal insulation properties of these boards were found to be much superior over other commercial wood composite panels.

Properties of low-density particleboards from kenaf core, H. KAJITA, T. KAWASAKI and S. KAWAI: Proc. 4th Pacific Rim Bio Based Composites Symposium, p. 479, 2–5 November, Bogor, Indonesia (1998).

Raw material used was core of kenaf (*Hibiscus cannabinus*) with an air-dry density of 0.14 g/cm^3. Flake type particles were prepared with a Pallmann knife-ring flaker. Adhesive used was an isocyanate resin, WC-300 formulated by Japan Polyurethane Kogyo Co. Ltd. Boards with air-dry density ranging from 0.10 to 0.40 g/cm^3 were produced at three different resin contents in a range of 5 to 15% in solids based on the oven-dry weight of the particles. In this study, the effects of board density, resin content and pressing method (conventional hot-platen and steam-injection pressing) on the properties of the boards were investigated. The results obtained were as follows: 1) Boards produced with conventional hot-platen pressing had a density gradient in the thickness direction, generally, more compact in the face layers and less so in the core. Boards produced with steam-injection pressing had similar results. 2) Dry and wet (2-hr boiling) bending properties (MOR and MOE) of the boards produced by both pressing methods, had a tendency to increase with increases in the board density. No significant statistical change was showed between the two pressing methods. 3) Internal bond strength and thickness swelling after 24-h water soaking treatment had a tendency to increase with increases in the board density and the effect of resin content on these properties appeared clearly on the boards with a density of 0.40 g/cm^3. 4) The equilibrium moisture content of boards produced with steam-injection pressing was about 2 percent less than that of boards produced with hot-platen pressing. Most boards produced with steam-injection pressing had less thickness swelling than boards produced with hot-platen pressing. 5) The thermal conductivities of boards were 0.038 and 0.081 Kcal/mh°C for 0.10 and 0.40 g/cm^3 board densities, respectively. The sound absorption of boards with a density of 0.10 g/cm^3 was low in the low-frequency region, and high in the high-frequency region.

Optimum formation of isocyanate adhesives for wood, K. UMEMURA and S. KAWAI: Second International Wood Science Seminar, B23, 6–7 Nov., Serpong, Indonesia (1998).

In the wood composition board industry, the utilization of isocyanate adhesives has increased in the replacements of other traditional formaldehyde based adhesives. The main advantages of using isocyanate adhesives include high adhesive and cohesive strengths, low curing temperature, and no formaldehyde emission. The isocyanate adhesives are highly reactive chemical compounds which contain the -N=C=O group. This functional group is capable of reacting with compounds having active hydrogens such as alcohols, water, amines and acids. Generally, isocyanate compounds are reacted with polyols in the syntheses of urethane and urethane-urea polymers. Therefore, many types of polymers can be obtained according to the different formulations of isocyanates and polyols. However, polymeric diphenylmethane diisocyanate (P-MDI) has been commonly used as isocyanate adhesives for wood. To date, only a few studies have been conducted on the effects of polyols addition on P-MDI.

To obtain a good bonding performance, optimum formulations of isocyanate adhesives for wood were investigated using an aqueous emulsion type polymeric diphenylmethane diisocyanate (E-MDI) and several types of polyether polyols. The polyols were added at a NCO/OH ratio of 25, and water was also added to obtain a final NCO/OH ratio of 0.5. In addition, only water was added at NCO/OH ratio of 0.5 and were used as the adhesives for bonding 3-ply plywood samples. The dynamic mechanical properties and shear strength of the resin adhesives and plywood were measured, correspondingly. When the dipropylene glycol type polyethre polypol with relatively low molecular weight was added to the E-MDI besides water, the cured resins exhibited good thermal stability up to about 280°C. Compared to the resin cured with only water, the thermal stability was dramatically improved by polyol addition. The average bond strength of only water added resin was 21.7 MPa. In the case of the polyol added resins, the average bond strength recorded was 25.6 MPa. Therefore, the bond strength could be improved by about

18% via polyol addition, compared to addition with only water.

The formation and effects of density profile in particleboard and fiberboard—A brief comparison—, E. WONG, M. ZHANG, P. YANG and S. KAWAI: Second International Wood Science Seminar, B25, 6–7 Nov., Serpong, Indonesia (1998).

One of the most economic means to obtain the desired properties in lignocellulose-based composites is via manipulation of the production process. The production of particle- or fiber-based composite boards require the blended components of resin and particles/fibers to be formed into mats and platen-pressed to form a board. The complicated interactions among heat, moisture and pressure during hot pressing results in the formation of a density profile along the thickness of the board, which typically resembles a "U"-shape. This density profile provides, amongst others, the mechanical strengths and surface hardness of the particleboard and fiberboard.

A comparison of the particleboard and fiberboard (with homo- and conventional density profiles) produced from lauan (*Shorea* spp.) and isocyanate resin adhesive showed that the density profile of fiberboard could be varied to a greater extent compared to particleboard, especially at lower board mean density (MD). The results of the experiment show that the bending properties of the board is the most affected by the density profile. Based on the experimental data, the specific effect of peak density is greater at higher MD for both particleboard and fiberboard. For particleboard at 0.7 g/cm^3 MD, the MOR and MOE increased by about 23 and 40%, respectively, when PD increased from 0.7 to 1.0 g/cm^3. In the case of fiberboard, the corresponding improvements in the MOR and MOE were 57 and 37%, when PD increased from 0.7 to 1.1 g/cm^3. According to the analysis by finite element method, the effects of PD were however, less significant than the above values. The internal bond strength and wood screw withdrawal resistance depend mainly on the core and mean densities, respectively. Homo-profile particleboard recorded better dimensional stability than conventional particleboard throughout the dry/wet conditioning cycle, whereas fiberboard showed a reversed trend.

Thermal insulation properties of low density fiberboard and veneer-Overlaid fiberboard, T. KAWASAKI, M. ZHANG and S. KAWAI: Second International Wood Science Seminar, B26, 6–7 Nov., Serpong, Indonesia (1998).

Fiberboard is useful as material for thermal insulation because of its porous structure. This wood-based product is both economic and environmentally friendly, as it can be produced from low grade logs and wood wastes, and be recycled. This paper discusses the thermal insulation properties of ultra-low density fiberboards and veneer-ovealaid fiberboards.

Low-density fiberboards (0.05–0.50 g/cm^3) and veneer-overlaid fiberboards (0.3–0.5 g/cm^3) were manufactured with steam injection pressing. The softwood fiber for fiberboards and the core of veneer-overlaid fiberboards was blended with an isocyanate compound resin adhesive at 10 and 30% resin contents and formed into fibermats. The lauan rotary veneers of 0.55–2.0 mm thickness were spread with the same resin type at 75 g/m^2, and overlaid on the top and bottom faces of fiber-mat. The fiberboards and assembled veneer-overlaid fiberboards were then pressed into boards of 370×360×12 mm with steam pressure of 0.6 MPa at 160°C. The total pressing time was 3 minutes including 2.5 minutes of steam injection for all boards. The thermal conductivity of the fiberboards and veneer-overlaid fiberboards were tested on one air-dried, 50×50×12 mm specimen from each board at 6–7% moisture content in accordance with the American Society for Testing Materials (ASTMC518-76).

The results showed that the thermal conductivity of fiberboards and veneer-overlaid fiberboards was more strongly influenced by the board density, rather than their construction. For lower density fiberboards, thermal conductivity approaches 0.02 kcal/mh°C of dried air at 20°C and is almost the same as those of other insulation materials such as rock wool, fiberglass wool, and polystyrene foam. For density ranging from 0.3 to 0.5 g/cm^3, thermal conductivity of veneer-overlaid fiberboards ranges from 0.05 to 0.08 kcal/mh°C, which is much lower than those of commercial plywood, hardboard and particleboard.

Cement bonded particleboard from non-wood lignocellulosic materials, S. KAWAI, B. SUBIYANTO; L. MA, D. HERMAWAN, I.M. SULASTININGSIH, T. HATA and H. SASAKI: Second International Wood Science Seminar, B28, 6–7 Nov., Serpong, Indonesia (1998).

This paper deals with the production of cement bonded particleboard and fiberboard from non-wood lignocellulosic materials which usually show inhibitory effect on the hydration of cement.

The hydration temperatures of bamboo or oil palm frond powder and cement mixtures with or without additives were examined. The inhibitory index (I-value) and compatibility factor (C_A-value) for each mixture were determined and the compatibility of each additives with the hydration of cement was evaluated; low values of hydration temparature peaks (T_{max} were observed for both the bamboo-cement and oil palm cement mixtures without additives. The presence of inhibitors in the cement mixtures resulted in lower T_{max} compared to neat cement. Magnesium chloride ($MgCl_2$) and calcium chloride ($CaCl_2$) as additives improved the comparibility of bamboo-cement, whereas $MgCl_2$ improved the oil palm-cement compatibility. Larger amounts of additives, in general, resulted in higher T_{max} values.

The cement bonded particleboards from bamboo, and cement bonded fiberboards from oil palm frond were successfully manufactured by using the conventional cold pressing method with the above additives. The mechanical and dimensional properties of the boards were tested in accordance with the Japan Industrial Standard, JIS A5908. In order to obtain adequate mechanical strengths, 10–15% of $MgCl_2$ or $CaCl_2$ and 7.5–10% of $MgCl_2$ were needed for bamboo-cement particleboard and oil palm-cement fiberboard, respectively. Tmax of C_A-value were found to be highly correlated to the mechanical properties of boards.

Research and development of the new rapid curing process technologies for the production of cement bonded particleboard/fiberboard by using steam-injection and hot pressing methods are also discussed.

New technology for manufacturing high-strength wood cement compositec by using super critical fluid of carbon dioxide, D. HERMAWAN, T. HATA, K. UMEMURA, S. KAWAI, S. KANEKO, W. NAGADOMI, Y. KUROKI and K. TSUNODA: Second International Wood Science Seminar, B29, 6–7 Nov., Serpong, Indonesia (1998).

This paper introduces a new revolutionary technology of manufacturing high-strength wood-cement composites using conventional cold-pressing method, followed by treatment with super critical fluid (SCF) of carbon dioxide, CO_2. Super critical fluids are useful in industrial operations where the properties of products can be favorably mainpulated by using pressure and/or temperature.

The mechanical properties of cement-bonded particleboards (CBP) produced from Japanese cypress (*Chamaecyparis obtusa* Endl) and Japanise cedar (*Cryptomeria japonica* D. Don) by using conventional cold pressing method with or without treatment with SCF of CO_2 were examined. CBPs of 12×250×250 mm with a target density of 1.2 g/cm^3 were produced at weight ratios of cement to particle (oven-dried weight) and water to cement of 2.2 : 1 and 1 : 2, respectively. The hand-formed mats of 300×300 mm were cold-pressed to the targeted thickness of 12 mm and kept in an oven set at 45°C for 24 hrs. The boards produced were then treated with SCF of CO_2 at 50°C under a pressure of 60 kgf/cm^2 for 1.5 hrs, and further placed in an oven set at 80°C for 10 hrs, followed by conditioning at ambient temperature for one week. The CBP without SCF treatment was wrapped with PVC sheet immediately after clamping and kept for 2 weeks at room temperature, followed by drying and conditioning under the same conditions as above. For control, CBP was produced without SCF treatment and dried at 80°C for 10 hrs immediately, followed by 1-week conditioning at room tempaerature.

The mechanical properties of the boards were tested in accordance with the Japan Industrial Standard, JIS A 5908. The results showed that the properties of the boards produced by conventional method were improved significantly by treatment with SCF of CO_2, the values of MOR and MOE of SCF treated CBPs were 23 Mpa and 5.3 Gpa, respectively, which were almost twice the values recorded by the control and boards without SCF treatment, with high internal bond strength and low thickness swelling.

Production and fire resistant performance of cement bonded particleboard and other wood based materials, F. ANITA, E. SUSETYOWATI, B. SUBIYANTO, T. HATA, S. ISHIHARA and S. KAWAI: Sencnd International Wood Science Seminar, B31, 6–7 Nov., Serpong, Indonesia (1998).

Cement Bonded Particleboard (CPB), Particleboard (PB) and Medium Density Fiberboard (MDF) are prospective materials due to its attraction in extending the use of waste in wood inductries, forest and agricultural residues which have been considered as environmental problems. Producing such wood based panels can support the effort to maintain the sustainability of tropical forest as the resource of oxygen production. As an alternative builing materials, cement bonded particleboard and other wood based materials offering an assortment of benefits such as could be designed as proposed utilization, giving more alternative in the dimension and in some cases giving a longer service life time than solid wood. Testing the performance of fire resistance of CPB and other wood composite material will be beneficial step for preparing the evaluation of the entire performance of composite materials as its need as building material or other utilization. A new method for evaluating the fire resistant performance of wood based panels is examined as a method which providing the procedures for testing the fire performance of boards based on its density and thickness.

This paper discuss the production of CPB and PB in various densities and thickness and then continue through evaluation of physical and mechanical properties of PB, CPB and MDF which consist of such as Internal Bond (IB), Thickness Swelling (TS), Moisture content (MC), Density, Modulus of Rupture (MOR), Modulus of Elasticity (MOE) and the examination of new testing methods of fire performance resistant of boards.

The test result of particleboabd shown that most of the type of boards could achieve the value for the strength, but, on the other hand, could not achieve the maximum value of thickness swelling and water absorption and this happen mostly for laboratory making boards. It is predicted that the absence of wax in the production mixture affected such performance. Only PB12 board had the lowest value of MOR and could not achieve the standard and this was mostly affected by the lower density of the produced board. For the MDF, all the board types could achieve the minimum value of the strength and also achieve the maximum value of thickness swelling and water absorption. All of the CPB board also pass the JIS value in the strength aspect as well as physical properties.

MDF in 3 mm thickness which mean the lowest surface density of board has the worst fire resistance and CPB with 18 mm thickness is the best. Although in the same board type, it tends that the higher surface density the better fire performance of materials but among one type to others seems that surface density is not the only key factor affected the fire performance, however, thickness of board giving more effect to the fire performance. For PCB, there was not even one flame board but data in Table 1 shown that CPB with surface density 15, 47 reach the 160, 240, 250°C and 260°C temperature in less time than particleboard with lower surface density but thicker. The heat transfer of cement board is faster than particle board but in CPB there was no flame, although in some samples it seem that cracks happen in the exposed center point of CPB. Characteristic of materials especially in related with the heat transfer capability affected the fire resistant performance of boards.

Possible uses of carbon materials to improve the fire retardancy of wood composites, SUBYAKTO, T. HATA, I. IDE, S. KAWAI and Y. IMAMURA: Second Intrnational Wood Science Seminar, B42, 6–7, Nov., Serpong,

Indonesia (1998).

Carbon materials made from wood, wood waste and other biomass have been commonly used for fuel, metallurgical and chemical industries. In dhe field of wood composites, some works on the application of carbon materials to improve the electromagnetic shielding efficiency, physical and mechanical properties and fire resistance have been comducted. In this paper the basic thermal properties of carbon phenolic materials and its application on the wood composite were discussed.

To observe the basic properties of carbon materials, the anisotropy in thermal properties of carbon phenolic spheres (CPS) made by hot pressing the mixture of carbon graphite/wood charcoal and phenolic resin were characterized. The results show that the ratio of thermal diffusivity and thermal conductivity between horizontal and vertical direction was much larger compared to uncarbonized CPS. The ratio of thermal diffusivity in horizontal to vertical direction of CPS carbonized at 1,000°C was about 30, uncarbonized CPS was 9.5, while that of solid wood was 2.5. The anisotropy in thermal properties found in the CPS might be used to develop fire retardant made from charcoal for wood composite.

To improve the fire resistance of wood composites, carbon-graphite phenolic spheres (GPS) was reinforced to the joint of laminated veneer lumber (LVL). The timber joint usually connected with metal joint wares is considered as a weak point when subjected to fire. The LVL joints reinforced with WPS and without reinforcement were exposed to fire and load at the same time. The results show that the fire performance of the joint was remarkably improved due to the GPS reinforcement. The time to rupture of the joint veinforced with GPS-layer (10 by 135 mm, three sides) was more than 5 times longer compared to that of control (without GPS reinforcement).

Predicting the compatibility of some Indonesian bamboos with cement by hydration test, I.M. SULASTININGSIH, L. MA, M.Z. AMIN and S. KAWAI: Second International Wood Science Seminar, C198, 6–7 Nov., Serpong, Indonesia (1998).

The hydration tests were carried out to determine the compatibility of some Indonesian bamboos with cement. The bamboo species used in the tests were *Dendrocalamus asper, Gigantochloa apus, G. pseudoarundinacea* and *G. levis* collected from Bogor. The results show that the compatibility of bamboos as cementbonded board raw material varies both from the bottom to the upper part of the bamboo colum and among the species. *Gigantochloa apus* can be used directly as raw material for cement-bonded board, whereas the others have to be added with some chemical accelerators. Magnesium chloride ($MgCl_2$) and calcium chloride ($CaCl_2$) can improve bamboo cement compatibility at the minimum level of 2.5% and 5%, respectively, of the cement weight.

Production technology of oil palm cement bonded particleboard I, Hydration behaviour of cement mixed with powder oil palm fronds, B. SUBIYANTO, I.M. SULASTININGSH, D. HERMAWAN K. UMEMURA, T. HATA and S. KAWAI: Second International Wood Science Seminar, C207, 6–7 Nov., Serpong, Indonesia (1998).

The hydration behavior of cement mixed with oil plam fronds using some type of accelerators and content were determined. The accelerators in the experiment were used magnesium chloride ($MgCl_2$), sodium hydro carbonate ($NaHCO_3$), and sodium silicate (Na_2SiO_3). The amount of accelerator were varied 0, 2.5, 5.0 and 7.5% for $MgCl_2$, then it were combined with $NaHCO_3$ and $NaSiO_3$ and Na_2SiO_3 with varied weight of 0, 5, 10 and 15% based on weight of cement. The unfavorable of oil palm fronds as raw materials of cement bonded particleboard as shown in the behavior of cement hydration was significant reduced by using accelerators. The accelerators, $MgCl_2$, Na_2SiO_3 and its combination on the average produced a compatibility factors of above 68%, when applied at 7.5 percent for $MgCl_2$ and above 10 percent for Na_2SiO_3. It is probable and these asselerators will beneficially impact fronds of oil palm when mixed with portland cement and acceptable boards can be made from such inhibory materials as fronds of oil palm.

Improvement on the dimensional stability of MDF made from oil Palm fibers by plazma treatment, K. OHONUSHI, Y. OKUDAIRA, Y. SAWADA and S. KAWAI: Utilization of Oil Palm Tree, p. 61–66 (1996).

Atmospheric pressure glow discharge plasma (APG plasma) treatment was carried out to improve the dimensional stability of MDF made from oil palm frond and trunk fibres. The obvious effect of hydrophobic treatment with APG plasma on TS (thickness swelling) and water absorption was observed. The hydrogen radicals activated by plasma react on the hydrophilic hydroxyl groups on the fibre surface, and impart hydrophobicity on the MDF made from oil palm fibres. Furthermore, the strength of the oil palm frond fibre was measured and compared with that of softwood fibre. The MOR of the MDF made from these materials was evaluated. The MDF made from frond fibre had greater MOR than that from softwood fibreboard. This performance is considered to be due to the higher tensile strength of the frond fibre. From the experimental results, MDF made from oil palm fibres was found to have sufficient potential to warrant investigation of their application as actual building materials.

New processing technology for aligning lignocellulosic fibers, S. KAWAI, K. OHNISHI, R. SUGAWARA, Y. OKUDAIRA and M. ZHANG: Intern'l Conference on Effective Utilization of Plantation Timber, p. 109–114, 21–23, May, Chi-Tou, Taiwan (1999).

This paper deals with a new technology for aligning long lignocellulosic fibers from oil palm, kenaf, bamboo, etc. for manufacturing oriented medium density fiberboard (MDF). A mechanical orientor was designed, set-up and trial tested. The newly developed orientor consists of many pairs of upper and-lower rollers through which fibers are stretched and straightened. These fibers are subsequently passed in between a pair of rubbing belts where they are yarned into fiber bundles. Kenaf bast fiber and oil pahm empty fruit bunch fiber were used for trial manufacturing of oriented MDF using the mechanical orientor developed.

High-strength oriented MDFs bonded with an iso-

cyanate resin adhesive were successfully manufactured. Kanaf MDF of 0.8 g/cm^3 density recorded moduli of elasticity (MOE) and rupture (MOR) of 16.8 GPa and 116 MPa, respectively, parallel to the fiber oriented direction. The ratios of parallel MOE and MOR to the corresponding values in the perpendicular direction were 12.9 and 8.2, respectively.

Upgrading of UF-bonded straw boards using silane coupling agents, G. HAN, K. UMEMURA, S. KAWAI and H. KAJITA: Intern'l Conference on Effective Utilization of Plantation Timber, p. 229–235, 21–23, May, Chi-Tou, Taiwan (1999).

Reed and wheat straw particleboards bonded with UF resin were manufactured from fine and coarse particles in a density range of 0.55–0.90 g/cm^3. The effects of particle dimensions and board density on the board properties were examined. The properties of the straw pabticleboard were relatively lower compared to those of commercial particleboard. The board properties were improved by the addition of silane coupling agents (SCAs). To clarify the causes of inferior bonding properties and improvement mechanism of UF-resin bondability by the addition of SCAs, the effect of SCAs on the wettability of straw surfaces was investigated. The distribution of silicon in straws was analyzed by using ESCA. The inherent wettability of the straws was quite low, but could be improved by treating with SCAs. The ESCA analyses revealed that there was much silicon on both the outer and inner surfaces of reed straw, but only on the outer surface of wheat straw.

Manufacture and properties of lignocellulosic based eco-materials, M. ZHANG, Y. HATANO and S. KAWAI: Intern'l Conference on Effective Utilization of Plantation Timber, p. 236–241, 21–23, May, Chi-Tou, Taiwan (1999).

This paper reviews the manufacture and properties of 5 types of composite boards using fibers, particles and strands from lignocellulosic materials such as bamboo, jute, bagasse, and herbaceous plants. These boards include jute/wood composite fiberboards (JF-WF) made from mixtures of jute fiber (JF) and wood fiber (WF); three-layered composite boards (BS/WF/BS) with bamboo strands (BS) and WF as face and core materials, respectively. Bamboo fiberboards with honeycomb structure were also manufactured by using bamboo fibers of different size. One species of herbaceous plant, chigaya (common Japanese name), was chosen as raw material for particleboard production. Three-layered bagasse boards were also manufactured by using steam-injection pressing.

The influences of processing parameters such as adhesive type, fiber or particle configurations, board structure, and hot pressing method on various board properties were examined.

Recycling of wood based materials, S. KAWAI: Kentiku Tishiki, March, p. 176–177 (1998) (in Japanese).

Recycled wood from houses is reviewed and recent progress of recycling technology for wood resources is introduced.

Wood based composition boards, S. KAWAI: *Wood Industry,* **53**(11), 507–509 (1998) (in Japanese).

The past, today and future development of particleboard and fiberboard industry in Japan is briefly introduced.

LVL system feasible for regional forest management, S. KATO, S. KAWAI and H. SASAKI: *Wood Industry,* **54**(1), 26–28 (1999) (in Japanese).

The small scale production system of laminated veneer lumber feasible for regional forest is discussed and designed.

Newly developed composite panels, S. KAWAI: The Encyclopedia of Wood Industry, ed. Wood Technological Association of Japan, p. 190–191, Feb. (1999) (in Japanese).

Newly developed composite panels, such as MDF faced strandboard, foam core sandwitch panels, plywood/OSB overlaid low-density fiberboard, laminated veneer board, and stickboard were briefly introduced.